NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

BEN E. DOUGLAS, DIRECTOR

DIVISION OF MINERAL RESOURCES

JASPER L. STUCKEY, STATE GEOLOGIST

BULLETIN NUMBER 67

THE COMMERCIAL GRANITES OF NORTH CAROLINA

BY
RICHARD J. COUNCILL

RALEIGH

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LETTER OF TRANSMITTAL

Raleigh, North Carolina

February 15, 1954

To His Excellency, GOVERNOR WILLIAM B. UMSTEAD
Governor of North Carolina

SIR:

I have the honor to submit herewith manuscript for publication as Bulletin No. 67, "The Commercial Granites of North Carolina," by Richard J. Councill.

Bulletin No. 2, "The Building and Ornamental Stones of North Carolina," which was published in 1906, has been out of print for several years. The importance of granite as a building material has increased rapidly in recent years. North Carolina is well supplied with granite, and it is believed that this report will be of considerable value to those interested in the granite resources of the State.

Respectfully submitted,

BEN E. DOUGLAS,
Director

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INTRODUCTION

The widespread deposits of granite and related crystalline rocks and their utilization in the production of various types of crushed and dimension stone constitute a principal mineral industry in North Carolina. From a small production prior to 1900, the quarrying and manufacturing of commercial granite in North Carolina has shown a continued increase, and in 1950 the value of these products amounted to almost one-third of the total value of minerals and mineral products marketed in the State. According to the latest published figures (U. S. Bureau of Mines, Minerals Yearbook, 1950), the State ranks first in value of marketed crushed granite and seventh in value of dimension granite output. Unpublished figures for 1952 indicate granite production is still rising in North Carolina. More than 95 percent of the commercial granite produced in North Carolina comes from the Piedmont Plateau region of the State; however, large deposits, which offer excellent opportunities for commercial use, are available in the Coastal Plain and Blue Ridge or Mountain regions.

Throughout the past half-century of expansion in the stone industry of the State such rock types as sandstone, quartzite, slate, marble, and limestone have contributed appreciably to the overall production of rock but always have occupied a subordinate position in comparison with the production of granite and related rocks. The primary reasons for the predominance of granitic rocks as the largest source of commercial stone in North Carolina are related to three conditions of occurrence, as follows: (1) Granite exists in large volume; (2) the deposits of granite are readily accessible in many localities; and (3) the superior quality of granite for use as building stone and crushed aggregate has resulted in a perennial market in the State and outlying areas.

The potential value of the varied stone resources of the State was recognized early, and in 1904 a systematic study was begun under the direction of the North Carolina Geological Survey for the purpose of evaluating the granite, sandstone, and marble deposits of North Carolina. The subsequent report, based on the field and laboratory work done by T. L. Watson and F. B. Laney and titled, "The Building and Ornamental Stones of North Carolina," contains detailed information regarding location, mode of occurrence, uses, physical and chemical characteristics of stone deposits of North Carolina, and the extent of their utilization. Since its publication in 1906, this report has served as a valuable guide to the stone resources, especially granite, in North Carolina; however, it is no longer available for public distribution, and the need for a new report of this type is mandatory in the light of the increased importance and continuing growth of the stone industry in the State. Because granite and related crystalline rocks constitute the principal commercial stone deposits of North Carolina, this report has as its primary purpose a re-evaluation of the granite resources, and it is designed as a guide to the granite industry and the areas of present and potential granite production. It contains information pertaining to the economics of rock-quarrying, the origin and composition of granite, its physical and structural properties, descriptions of the areas in North Carolina in which granites occur and are utilized commercially, the principal methods of granite-quarrying, and the various methods of testing the durability of both dimension and crushed stone.

METHODS OF INVESTIGATION AND ACKNOWLEDGMENTS

The information contained in this report represents the results of fieldwork done intermittently during the late summer and early fall of 1952, the winter of 1953, and laboratory work done in the spring of 1953. A large part of the work consisted of visiting the more important operating quarries, a few of the presently abandoned quarry localities, and some potential quarry sites. The general characteristics of the rocks were studied at the quarries; quarry superintendents and local inhabitants were consulted concerning the production and history of each quarry visited; and representative samples of granite were taken at most operating quarries and some potential quarry sites for petrographic analyses. Measurements of the strike of the joint systems were made, along with observation of other structural features present in the rock bodies, and the size and shape of each quarry visited were noted in order that an estimate could be made of the amount of rock removed. Other significant features, such as, thickness of overburden and depth of rock decay in the quarry areas, were also given attention. The methods of quarrying, transportation facilities, and equipment used in cutting or crushing at the quarries were also observed during the field investigation. About a third of the fieldwork was devoted to studies of the quarries in Rowan and Surry Counties, where

the dimension granite industry of the State is centered. Laboratory work for the report consisted of megascopic examination of all rock specimens collected and petrographic analyses of the rock types from representative granite areas across the State.

The fieldwork and compilation of data for this report were done under the direction of Dr. Jasper L. Stuckey, State geologist, who also supplied much general information concerning the granites of North Carolina. Clifton M. Gibbs, a student at North Carolina State College, ably assisted in the field investigation during August and September 1952. Mr. Gibbs also did a large share of the cartographic work accompanying this report.

Grateful acknowledgments are due Messrs. Hosselton and W. W. Rogers of the J. A. Logan Granite Company; Messrs. W. L. Harris and G. A. McKenzie of the Harris Granite Quarries Company; Messrs. J. P. Frank and John Simmons of the North Carolina Granite Corporation; Mr. C. R. Deadwyler of the Salisbury Granite Industries; Mr. L. M. Seawell of the Piedmont Quarries; and Mr. H. S. Satterwhite of the Bryan Rock and Sand Company for their cooperation in familiarizing the author with quarrying operations and the general economy of rock-quarrying. The author also wishes to express appreciation for the invaluable information supplied by the many quarrymen in North Carolina. Mr. A. C. Dodson, geologist, and Mr. H. F. Waller, Sr., laboratory technician, of the Division of Materials and Testing of the North Carolina State Highway and Public Works Commission supplied valuable information and test results concerning the testing of crushed stone from commercial and State quarries in North Carolina. For this information, the writer is greatly indebted. The information gathered in the preparation of this report is in some instances complemented by various data from the Watson and Laney report of 1906, and many of the petrographic descriptions herein were taken from that publication.

GRANITE DEFINED

The term granite as used in this report has general reference to very siliceous, massive plutonic rocks. In its commercial sense, it includes true granite, granodiorite, quartz-monzonite, and rarely diorite and gabbro.

Granite as a distinct rock type may be defined as a massive igneous rock of plutonic origin, displaying a crystalline texture and containing as essential mineral constituents orthoclase or microclinic feldspar, quartz, and one or more dark iron silicate or ferromagnesian minerals, usually biotite or hornblende. Muscovite sometimes occurs with or replaces the ferromagnesian mineral in granite. Most granites also contain small amounts of plagioclase feldspar, usually a high-soda variety (albite, oligoclase), and a more or less uniform distribution of one or more of the principal accessory minerals: epidote, magnetite, hematite, zircon, apatite, titanite, pyrite, and garnet. The averages of the principal minerals composing samples of granite from many localities are shown in column 5 of Table I. In instances where the mineral composition of the rock in a particular deposit fails to conform with the general average but has the appearance of normal granite (biotite granite), it is referred to in this report as granite or granitic rock, and a clarification of the general term is made in the petrographic descriptions.

Many of the so-called granites of North Carolina approach more closely the mineral composition of granodiorite and/or quartz-monzonite than normal granite. Such rocks differ from normal granite only in containing an excess of plagioclase feldspar and a corresponding decrease in potash feldspar. For example, granodiorite may be designated as a granite containing an excess of plagioclase over orthoclase and microcline with normal amounts of quartz and biotite or hornblende. Quartz-monzonite contains in essentially equal proportions plagioclase and orthoclase feldspar, together with quartz and biotite or hornblende. Another related rock found somewhat extensively in the central section of the State is termed syenite. Like the aforementioned types, it is genetically and texturally related and in many ways is like granite in chemical composition. These more or less acid siliceous rocks are often in complex arrangement with diorite and gabbro types of similar texture and occurrence, and in such areas the term "granite-diorite complex" is used to indicate the complex arrangement of rock types. Rocks in which the growth of certain mineral constituents is roughly parallel may also contain mineral percentages comparable to the massive plutonic rocks and are usually termed gneissic-granite, gneissic-granodiorite, or granite-gneiss. Commonly, it is the biotite or hornblende constituent of gneissic rocks which displays a marked parallelism. Table I lists the chemical

composition of several North Carolina granites and related rocks, together with the chemical composition and average mineral percentages of the principal rock types.

TABLE I. COMPOSITION OF GRANITE AND RELATED ROCKS

	1	2	3	4	5	6	7	8
	Granite Near Raleigh Wake County Percentage	Granite Near Mooresville Iredell County Percentage	Granite Dunns Mountain Rowan County Percentage	Granite Near Mt. Airy Surry County Percentage	Granite Average of 23* Percentage	Syenite Average of 50** Percentage	Diorite Average of 70** Percentage	Gabbro Average of 24** Percentage
SiO_2	69.28	66.01	75.14	70.70	69.35	60.19	56.77	49.50
Al_2O_3	17.44	17.44	16.10	16.50	14.27	16.28	16.67	18.00
Fe_2O_3	1.08	5.62		2.34	1.22	2.74	3.16	2.80
FeO	1.22				2.33	3.28	4.40	5.80
MnO	0.16	0.23	Trace		0.07	0.14	0.13	0.12
MgO	0.27	1.44	0.04	0.29	1.13	2.49	4.17	6.62
CaO	2.20	1.11	0.93	2.96	2.18	4.30	6.74	10.64
Na_2O	3.64	5.06	5.82	4.56	2.98	3.98	3.39	2.82
K_2O	2.76	3.16	2.57	2.45	5.36	4.48	2.12	0.98
Total	**98.05**	**100.07**	**100.60**	**98.80**	**98.89**	**97.88**	**97.55**	**97.28**
Average Quartz***					30.00			
Average Orthoclase***					45.00	60.00		
Average Plagioclase***					15.00	20.00	65.00	55.00
Average Mafics and Others***					10.00	20.00	35.00	45.00

* Modified after Johannsen
** Modified after Daly
*** Modified after Grout

ORIGIN OF GRANITE

Granites and related rocks are considered in this report as a solidified magma derivative, emplaced into the crustal portions of the earth while in a viscose liquid or plastic condition. This magma is a siliceous rock-melt, differentiated by simple density relationships from a subcrustal reservoir of magma in which the essential mineral components of granite crystallize in a complex but orderly fashion. Many of the crystalline rock bodies in the granite areas of the world owe their existence to the solidification of silica-rich magmas within the crustal portions of the earth; however, in recent years much controversy has centered around the purported metasomatic or metamorphic origin of granite, processes whereby pre-existing rocks, commonly sedimentary rocks, are changed in place to granitic rocks by metasomatic enrichment or solution privation, accompanied by recrystallization or by recrystallization under stress and without additions from sources outside the rock. These alteration processes, known as "granitization," are today widely accepted as the origin of some massive crystalline as well as gneissic rocks of granitic composition. Granites formed by both processes are present in North Carolina, but the relationship of the granite deposits to the adjacent rocks is extremely complex, and no attempt was made during the investigation to differentiate between "metamorphic granites" and igneous granite. However, the author is confident that such a separation can be accomplished by an intensive field and petrographic study of the massive crystalline rocks and the granite gneisses of the State that seem most likely to have had a primary sedimentary or previous basic igneous or metamorphic origin.

DIKES PENETRATING THE GRANITES

Throughout the granite areas of the State, dike materials of several different types have wide distribution. The types included in the intrusives are acid and basic dikes* and mineral veins, which range in tex-

*Author's Note: Acid dikes are composed largely of potash feldspar, quartz and subordinate amounts of mafic, or iron magnesium silicates. Basic dikes are composed of mafic and femic minerals, plagioclase, subordinate accessories, and little or no quartz.

ture from that of quartz veins through aplitic, granitoid, pegmatitic, and diabasic, with many of the basic dikes bearing a notable schistose structure. The dikes and veins may vary from an inch to several hundred feet in width and show great variation in strike direction.

Acid Dikes and Veins: In the granite areas of the State, veins and dikes of acid composition are distributed rather uniformly, and in some localized areas they constitute the major rock material. The dikes and veins range from pegmatitic to aplitic and in a few instances to a granitoid texture but are alike in a composition in which quartz and feldspar predominate, with more or less biotite as an accessory mineral. Pegmatite dikes are common, occurring in many of the granite areas and in some of the quarries. They are composed of white or pink feldspar and quartz grains, ranging from an inch to more than three inches across, which commonly display complex intergrowth. In most of the dikes, small plates of biotite or muscovite are found in minor amounts, and occasionally one or more granite accessory minerals are present.

Aplite dikes of exceedingly fine-grained to almost cryptocrystalline texture occur in many granite areas but are far less common than pegmatite. The most notable localities in which aplite occurs are Wake County, in the areas underlain by granite gneiss, and in northern Alamance County. Few were observed elsewhere. In composition, the aplite dikes are remarkably similar to the enclosing granite but generally contain little, if any, plagioclase. According to Watson and Laney, most aplites in the granite areas of the State should be placed with the "potash aplites." In size, the aplites range from less than one-half inch to about six inches in width and, so far as observed, occur entirely as dikes.

The presence of granitoid dikes in the granite areas of the State is comparable in occurrence to the pegmatite but are less abundant. Often associated with pegmatites, these dikes are distinguished by a smaller and more uniform grain size and sometimes by the conspicuous absence of micaceous or platy minerals, giving a binary or two-mineral granite. The size of these intrusives is varied, ranging from an inch to several feet in width. As a rule, the smaller dikes are composed of binary granite and are found throughout the granite areas, while the larger normal granite types are restricted more or less to certain localities in the Central Piedmont and are most abundant in the granite-gabbro-diorite complex. They can be seen penetrating both the granite and the gabbro-diorite and are most prevalent in contact zones.

Quartz veins are a common sight in the granite areas and usually show strongest development in the areas of pegmatitic intrusion. So far as determined, the quartz is restricted largely to joint and other open-fracture filling but occasionally occurs as "pseudo-veins," formed by the segregation of silica at the time of the crystallization of the granite magma. The veins range in width from knife-edge to large fissure veins 10 or more feet across and, like the pegmatites, are rather uniformly distributed through the granite areas of the State.

Basic Dikes: The most striking rocks intruding the granite consist of diabasic and schistose dikes of basic composition. Ranging in width from several inches to several hundred feet, the dikes are found in increasing numbers from the Coastal Plain westward into the Piedmont.

Schistose Dikes: This schistosity is developed parallel to the direction of strike and normal to any gneissic structure in the granite. Contacts with the country rock are sharp. In all localities observed, the basic dikes cut the quartz veins, which are assumed to coincide with the later phases of granite intrusion. The schistose dikes, which are most prevalent in the Central Piedmont, are various shades of dark green and are moderately to highly decomposed. According to Watson and Laney, the principal mineral constituent of the dikes is hornblende; however, it is likely that both amphiboles and pyroxenes are contained in the composition. The dikes paralleling the major joint systems in the granite usually show a marked schistosity in the contact zone with the country rock.

Diabase Dikes: In many localities and often proximately associated with basic schistose dikes are more or less massive diabase dikes of gabbro composition, which, like the schistose variety, seem to increase in number westward from the fall line to the Piedmont. Orientation of strike direction can be correlated roughly with principal jointing in the granite. In most localities, weathering of the dike material is in an advanced stage, and decomposition has imparted a light- to dark-brownish color to the dikes. In a few instances the decay is reddish brown.

PHYSICAL AND STRUCTURAL PROPERTIES OF GRANITE

DIMENSION STONE

General: The availability of granite for fine building and monumental purposes is dependent upon varied factors responsible for its physical makeup, such as, resistance to weathering, desirable color, uniform texture, an absence of injurious mineral constituents, and a susceptibility to abrasive polish. The principal factors in this determination are:

Dikes and Veins: The presence of dikes and veins in granite deposits is detrimental to uniformity of the quarried stone and in some instances weakens the enclosing rock. Small dikes, veins, and veinlets are often found in great numbers in granite deposits and usually render stone useless as a source of commercial dimension stone.

Segregations and Inclusions: Mineral segregations and inclusions in granite deposits tend to disturb textural uniformity, mar the eye appeal of the finished product, and resist polish. The excessive segregation of biotite, muscovite, and amphiboles is quite common in granitic rocks and should be avoided when dimension stone of high quality is desired. Occasional small segregations of micaceous or platy minerals do not detract from the beauty of the stone, nor do they affect the ability to take abrasive polish.

Texture: Texture in igneous rocks has reference to individual grain size and fabric within a given intrusive mass and is perhaps the principal requisite of stone for use in building and ornamental work. Texture in the granites and related rocks ranges from aplitic, through fine-grained, medium-grained, large-grained, to porphyritic, all of which may or may not show fabric or a systematic arrangement of individual mineral grains. Textures result from several factors' influencing the change of a magma from a liquid or plastic state to a consolidated mass. These factors, in order of general importance are rate of cooling, pressure, and the presence of mineralizers. In general, rapidly-cooling magmas tend to form rocks of fine-grained size and uniform texture; whereas, under similar pressure conditions, slow-cooling masses form rocks made up of large grains of irregular size. That pressure indirectly influences texture is well agreed upon, but the degree of influence is purely theoretical. The gases held in solution under pressure are responsible for certain controls, since it is believed that gases dissolved in magmatic water (mineralizers) control the viscosity of the magma. With the partial release of pressure, the gases volatilize, remain in the rock-melt, and apparently reduce the viscosity of the magma, thus permitting a more rapid diffusion and subsequent growth of larger crystals to produce a porphyritic or large-grained rock. If pressures on the crystallizing magma are absent, the gases escape rapidly and a rock of finer texture results. Intermediate conditions undoubtedly exist, so that, many grain sizes are possible, depending on differences in pressure and the consequent volume of mineralizers allowed to remain in the rock melt. In addition to the normal functions in the granite magma, the escaping of the mineralizers is probably instrumental in the extension of a granite body by gaseous liquid assimilation or granitization of the surrounding older rocks. The principal grain sizes or textures reflecting pressure and relative temperature present during the solidification of granite magma fall into four general classes:

(1) Granite porphyry, or very coarse-grained granite, is composed of mineral grains more than one inch across. The feldspars are most frequently the largest grains in granite porphyries and usually show complex intergrowth with large quartz grains, as in graphic granite and alaskite. The common accessory minerals—biotite, muscovite, and hornblende—generally remain considerably smaller than either feldspar or quartz; however, they may grow comparatively large, perhaps one or more inches across. Such occurrences of muscovite are found in the "alaskite" bodies in Western North Carolina. In some instances granite porphyries are quarried as dimension stone, but no rocks of this texture are known to be worked for this purpose in North Carolina.

(2) Large-grained granite consists of mineral grains one-half to one inch across. In the case of a granite of this texture, the feldspars also constitute the largest grain size and the accessory minerals, the smallest.

(3) Medium textures or even-granular granites are in greatest demand in the building and ornamental trade and may be considered to include those stones with individual mineral grains ranging from one twenty-fifth to one-half inch across. Smaller grains may exist within the rock in a subsidiary amount, acting as a

groundmass for the larger grains, but generally constitute a very small fraction of the total volume of the rock.

(4) Fine-grained granite is composed of mineral grains less than one twenty-fifth of an inch across and usually shows an even-granular texture.

Rift and Grain: Because granite is the hardest natural building stone and the most expensive to quarry and shape into a usable form, it is usual, preceding and during quarrying operations for dimension stone, to consider the two physical properties known in the quarrying industry as rift and grain. Rift is the direction along which the artificial fracturing of granite can be accomplished with greatest ease, and grain is a second direction of splitting, less strongly marked and usually at right angles to the rift. Both may be considered as obscure foliation of microscopic dimension, on the order of 0.09 mm. to 0.13 mm. in width. Rift and grain permit straight and relatively smooth breaks in the rock and add facility in quarrying and finishing methods.

The origin of rift and grain is obscure, although according to Dale (Dale, T. N., 1923) the two "fracture systems" result largely from the orientation or lining-up of the mineral constituents of the rock (primary or secondary foliation). However, rift and grain in granitic rocks may also result from the parallelism of cleavage directions of the minerals, by incipient or microscopic jointing caused by internal or external forces acting upon the intrusion, or by a parallel arrangement of fluidal cavities present in the quartz grains.

Sheeting: The vertical thickness of dimension granite is dependent upon either a natural or artificially-produced plane, running approximately parallel to the surface of the deposit and in essence dividing the body into sheets or layers of near-uniform thickness. The thickness of the sheeting plane (bottom joints) varies considerably from quarry to quarry, often being from 1 to 10 feet or more in dimension, and generally increases with depth. Natural sheeting planes, like rift and grain, are obscure as to origin; however, Dale considers in some detail most of the theories advanced concerning their origin and concludes their existence is primarily the result of the release of compressive strain. Sheeting is considered by the writer as the result of a progressive release of compressive strain during the erosion of overlying material, coupled with the expansion of the mineral constituents of the granite in response to solar heat. Sheeting, although not always present in plutonic rocks, is present in most commercial granite areas in North Carolina. The notable exceptions are the Mt. Airy district in Surry County and the Salisbury area of Rowan County, where artificial induction of sheeting is necessary for the successful quarrying of dimension stone of uniform thickness. A description of this method is presented in the section on quarrying.

Color: Uniformity of color over a large areal extent is a desirable feature in the marketing of granite for use in building and ornamental work. If colors are consistent, granite from a certain locality becomes famous through the years, and the demand for the stone continues to increase. The colors in granite are in large part dependent upon the intensity of chroma of the predominant feldspar, although mafic minerals, tinted muscovite, and quartz may contribute appreciably to the overall color of a stone. Characteristic colors are red, pink, gray, and "white." Granite deposits generally display a variety of colors.

Joints: Most granitic masses are traversed by one or more sets of vertical or nearly vertical joints, referred to as the "major systems" and the "secondary systems." The major system consists of two planes of jointing which intersect at or near 90 degrees and are usually accompanied by one or more secondary sets which form a junction at an angle more or less than 90 degrees. It is believed that these systems result from compressive or torsional strain, resolved into two components, each at an angle of 45 degrees with the straining force.

CRUSHED STONE

General: The physical and structural properties of stone for crushing are important considerations in both the quarrying procedures desired and the ultimate use to which it will be put. Toughness and hardness of the rock influence the cost of production, and the soundness of stone determines its fitness for general use.

Toughness and Hardness: The toughness of a stone is a measure of its resistance to impact, and hardness is a property based upon resistance to surface abrasion. Both of the properties are determined by the individual mineral percentages, the degree of weathering, the texture, and the fabric of the rock. The testing and determination of both these properties is accomplished in various ways, some of which will be discussed in a subsequent section.

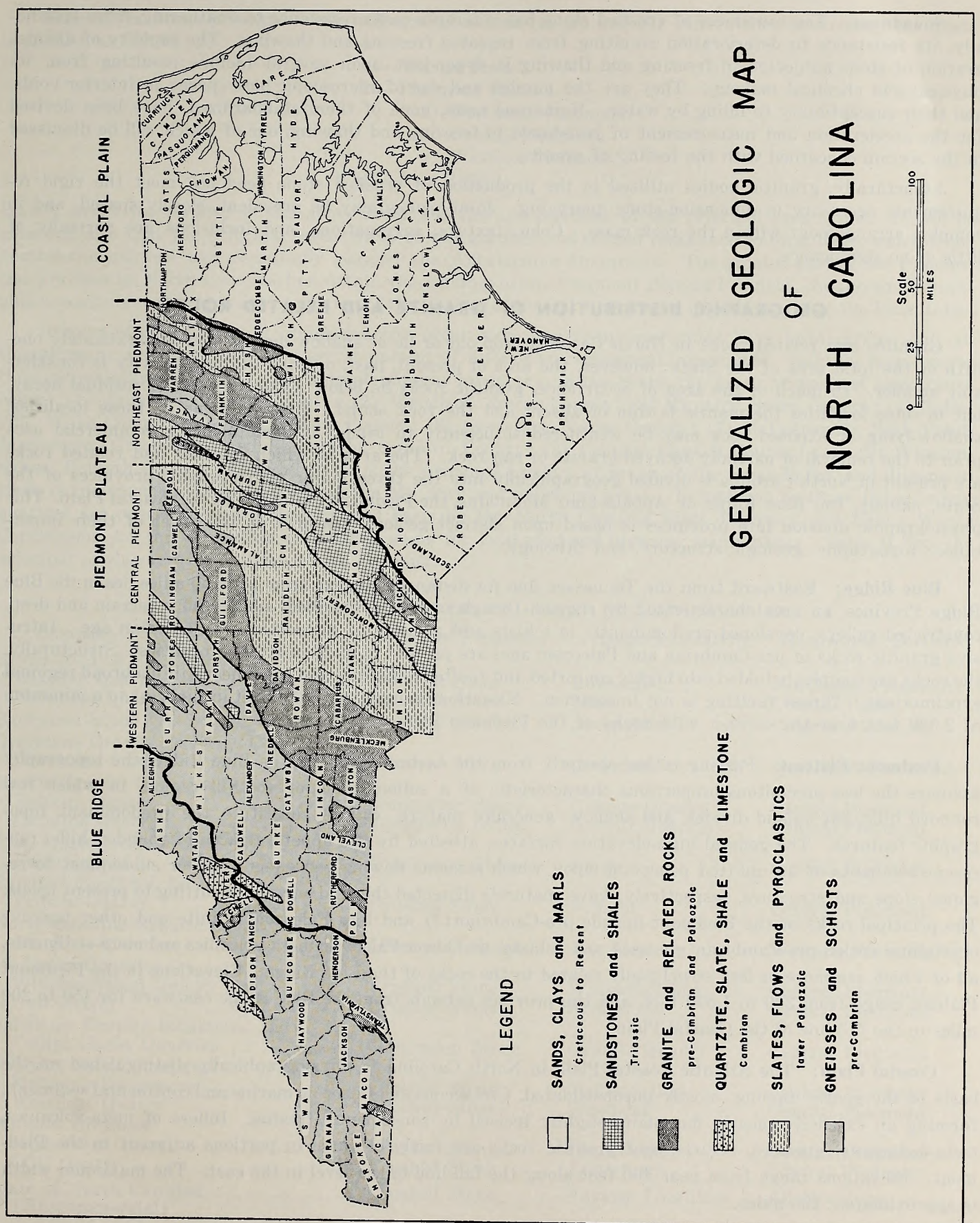
GENERALIZED GEOLOGIC MAP
OF
NORTH CAROLINA
BLUE RIDGE
PIEDMONT PLATEAU
COASTAL PLAIN
WESTERN PIEDMONT
CENTRAL PIEDMONT
NORTHEAST PIEDMONT
Scale
0 25 50 100
MILES
LEGEND
SANDS, CLAYS and MARLS
Cretaceous to Recent
SANDSTONES and SHALES
Triassic
GRANITE and RELATED ROCKS
pre-Cambrian and Paleozoic
QUARTZITE, SLATE, SHALE and LIMESTONE
Cambrian
SLATES, FLOWS and PYROCLASTICS
lower Paleozoic
GNEISSES and SCHISTS
pre-Cambrian

PLATE I

Soundness: The soundness of crushed stone has reference to its resistance to weathering, more specifically, its resistance to deterioration resulting from repeated freezing and thawing. The rapidity of disintegration of stone subjected to freezing and thawing is dependent upon several factors resulting from its physical and chemical makeup. They are the number and size of microscopic pore spaces, or interior voids, and their susceptibility to filling by water. Numerous tests, none of them standardized, have been devised for the acceleration and measurement of resistance to freezing and thawing, one of which will be discussed in the section concerned with the testing of granite.

Structurally, granitic bodies utilized in the production of crushed stone need not meet the rigid requirements necessary in dimension-stone quarrying. Joint planes may be prevalent, closely spaced, and in complex arrangement within the rock mass. Color, texture, segregations, and inclusions are normally of little or no significance.

GEOGRAPHIC DISTRIBUTION OF GRANITE AND RELATED ROCKS

Granites and related rocks in North Carolina crop out or lie at shallow depths over approximately one-fifth of the total area of the State; however, the area of present, past, or potential productivity is considerably smaller. In much of the area of occurrence, granitic rocks lie below a thick mantle of residual decay, but in some localities the mantle is thin or absent and the rock sound. Even in some of these localities, shallow-lying or exposed rock may be weathered sufficiently to render it unsuitable for commercial uses prior to the removal of partially decayed granite or sap rock. The area in which granites and related rocks are present in North Carolina is divided geographically into the three major physiographic provinces of the State, namely, the Blue Ridge or Appalachian Mountains, the Piedmont Plateau, and the Coastal Plain. This physiographic division into provinces is based upon distinct geologic features, in the order of their importance: topography, geologic structure, and lithology.

Blue Ridge: Eastward from the Tennessee line for distances ranging from 15 to 50 miles lies in the Blue Ridge Province, an area characterized by rugged, though somewhat subdued, mountainous terrain and deep, constricted valleys, developed predominantly in schists and gneisses of purported pre-Cambrian age. Intrusive granitic rocks of pre-Cambrian and Paleozoic ages are present in many scattered localities. Structurally, the rocks are complexly folded into highly contorted and faulted anticlines and synclines within a broad regional synclinorium. Thrust faulting is not uncommon. Elevations range from 6,000 feet in the west to a minimum of 2,000 feet near the contact with rocks of the Piedmont Plateau to the east.

Piedmont Plateau: Passing rather abruptly from the eastern limits of the Blue Ridge, the topography assumes the less precipitous proportions characteristic of a submontaine or foothill region, in which low rounded hills, flat upland divides, and shallow, generally mature, valleys constitute the predominant topographic features. The general high-elevation surfaces, attested by the upper surfaces of rounded hills, represent remnants of an uplifted peneplane upon which streams flowing consequent and/or subsequent to regional slope and structure, respectively, have maturely dissected the land surface in cutting to present levels. The principal rocks of the Piedmont include pre-Cambrian(?) and late Paleozoic granite and other massive crystalline rocks, pre-Cambrian gneisses and schists, and lower Paleozoic meta-volcanics and meta-sediments, all of which are more or less structurally related to the rocks of the Blue Ridge. Elevations in the Piedmont Plateau range from 300 to 1,500 feet, and the province extends from the Blue Ridge eastward for 150 to 200 miles to the fall line of the Coastal Plain.

Coastal Plain: The Atlantic Coastal Plain in North Carolina is physiographically distinguished on the basis of the gently dipping, mostly unconsolidated, Cretaceous and Cenozoic marine and continental sediments forming an extensive, nearly flat plain, slightly incised by consequent streams. Inliers of meta-volcanics, meta-sediments, gneisses, schists, and granitic rocks are fairly common in portions adjacent to the Piedmont. Elevations range from near 400 feet along the fall line to sea level in the east. The maximum width is approximately 125 miles.

Each of the three principal areas is discussed in this report, and for convenience in writing, the State is divided, as follows:

I—Coastal Plain
II—Piedmont Plateau
1. Northeast Piedmont
2. Central Piedmont
3. Western Piedmont
III—Blue Ridge.

Plate I shows the confines of the above areas and the age relations of the principal rock types. It will be observed also that the principal occurrences of the granites and related rocks tend to form belts, which trend northeast-southwest and essentially parallel the Appalachian Mountains. The greater part of the commercial granites in North Carolina lies within the confines of the Piedmont Plateau Province, though small workable deposits occur in the western portion of the Coastal Plain and at scattered localtities within the Blue Ridge.

In most of the counties in which granites occur some quarrying operations have been carried out, although many are quite small and are at present of little or no commercial importance. Only the large operations perennially contribute to the total mineral production in the State, the areas of greatest importance being: (1) Salisbury, Rowan County; (2) Woodleaf, Rowan County; (3) Mt. Airy, Surry County; (4) Rolesville, Wake County; (5) Sims, Wilson County; (6) Greystone, Vance County; (7) McLeansville, High Point, Jamestown, Greensboro, and Stokesdale, Guilford County; (8) Pelham, Caswell County; and, (9) Winston-Salem, Forsyth County. Crushed stone is the principal product of seven of the areas listed, and dimension stone is the most important product in the Mt. Airy and Salisbury areas. In addition to those listed, many quarries are operated on a noncommercial basis by the North Carolina State Highway and Public Works Commission for the production of crushed stone for local road and highway maintenance. Table II lists the principal producers of granite in North Carolina.

TABLE II. PRINCIPAL PRODUCERS OF GRANITE IN NORTH CAROLINA

Company	*Principal Product*	*Quarry Location*	*Geographic Division*
Bryan Rock & Sand Co.			
Lassiter Quarry	Crushed Stone	Rolesville	Northeast Piedmont
Neverson Quarry	Crushed Stone	Sims	Coastal Plain
Buchanan Stone Co.	Crushed Stone	Greensboro	Central Piedmont
Greystone Granite Quarries Co.			
Greystone Quarry	Crushed Stone	Greystone	Northeast Piedmont
Harris Granite Quarries Co.			
Balfour Quarry	Dimension Stone	Granite Quarry	Central Piedmont
Carolina Quarry	Dimension Stone	Granite Quarry	Central Piedmont
J. A. Logan Granite Co.			
Faith Quarry	Dimension Stone	Faith	Central Piedmont
Lambert Brothers, Inc.			
Pelham Quarry	Crushed Stone	Pelham	Central Piedmont
North Carolina Granite Corp.			
Mt. Airy Quarries	Dimension Stone	Mt. Airy	Western Piedmont
Piedmont Quarries Co.			
Winston-Salem Quarry	Crushed Stone	Winston-Salem	Central Piedmont
Guil Quarry	Crushed Stone	Stokesdale	Central Piedmont
Salisbury Granite Industries, Inc.			
Collins-Durax Quarries	Dimension Stone	Granite Quarry	Central Piedmont
Superior Stone Company			
McLeansville Quarry	Crushed Stone	McLeansville	Central Piedmont
Woodleaf Quarry	Crushed Stone	Woodleaf	Central Piedmont
Whitlow Brothers			
High Point Quarry	Crushed Stone	High Point	Central Piedmont
CCC Quarry	Crushed Stone	Jamestown	Central Piedmont
State of North Carolina (Noncommercial)	Crushed Stone	Various Localities	All Divisions

GRANITES OF THE COASTAL PLAIN

The Coastal Plain Province of North Carolina covers approximately two-fifths of the area of the State and includes 45 counties. The geographic separation of this province from the adjacent Piedmont is based on several prominent geologic features previously discussed and shown on Plate I. The line dividing the Coastal Plain from the Piedmont is hypothetical, in that it marks approximately the present westward extent in the State of sedimentary sands and clays belonging to the Coastal-Plain formations. It is known that the Cretaceous and younger sediments of the Coastal Plain unconformably overlie metamorphosed, slaty volcanic and sedimentary rocks and granites. Drilling logs from unpublished reports of oil exploration wells on the Coastal Plain report granite or slate as the basement rock, the granite being considered the younger rock because of similar types known to intrude rocks of the Volcanic-Slate Series in the Northeast Piedmont. The relatively small outcrops of granite within the Coastal Plain of North Carolina, therefore, represent inliers of the extensive subsurface crystalline rocks from which thin, loosely consolidated sediments have been eroded. The stripping of the Coastal-Plain sediments from the granites has taken place largely in areas adjacent to the major streams and their principal tributaries, near the contact with rocks of the Piedmont Plateau. Most of the outcrops in these areas tend to form elongated masses of ledge-like and boulder form and in cases where the outcrop is back from the stream, low, flat, or dome-like bodies.

The principal granite areas are found in Wilson, Edgecombe, Nash, Pitt, Anson, and Richmond Counties. In only one of these areas—at Sims in Wilson County—is granite being produced commercially; however, other deposits may merit investigation as future sources, especially in the Wadesboro-Rockingham area of Anson and Richmond Counties and around Rocky Mount in Edgecombe County. In almost all of the areas of fresh outcrop in the Coastal Plain, more or less systematic quarrying for dimension stone was done in the past, but it is doubtful that the rock in many of these areas will be utilized further.

WILSON COUNTY

With the exception of a few small areas, the entire central and eastern parts of Wilson County are covered by a thin veneer of Coastal-Plain sediments, overlying granite, volcanic slates, gneisses, and schists. The western portion of the county lies within the eastern prong of the Volcanic-Slate Series, but in a few localities granite has penetrated these older rocks and crops out at the surface as low dome-like masses.

CONTENTNEA CREEK AREA

About two miles south of Wilson on U. S. Highway 301, fresh granite is exposed through the sediments on both sides of Contentnea Creek for several miles upstream and along the adjacent areas a short distance back from the stream. The granite occurs as large boulders in the stream and as flat-surface masses in adjacent areas. It is a uniformly coarse-grained rock of dull pinkish-red color, becoming porphyritic in some places. Feldspar is the predominant mineral constituent of the granite, composing about 80 percent of the total volume, while quartz constitutes approximately 15 percent. Biotite, largely altered to chlorite, and a very small amount of apatite make up the remainder of the rock. Three sets of joints separate the granite into blocks of various sizes, striking almost N., N. 65° W., and N. 50° E. None of the joints are filled with vein or dike materials. Watson and Laney describe a section of the rock petrographically, as follows:

> "Plagioclase nearly equals in amount the potash feldspar, which consists mostly of orthoclase though some microcline occurs. Plagioclase is in very large laths, finely striated and corresponds in physical properties to albite. The feldspars are extensively altered to kaolin and muscovite. . . . Quartz is in very large grains interlocking with the feldspar and will probably not exceed 15 percent of the entire rock."

The rock falls into the type defined by mineral composition as quartz-monzonite. The rock is of good quality and appearance but is poorly situated for utilization as commercial stone.

SIMS AREA

This area contains a small body of granite, forming the main deposit on which the Neverson Quarry is located. It lies about one mile west of Sims along U. S. Highway 301 and immediately adjacent to the

Norfolk and Southern Railway. Though the area lies outside the Coastal Plain, it is discussed here because of close proximity to the fall line and further because it is located within a county lying partly within the Coastal Plain Province. The deposit is a conspicuous dome-like outcrop, covered in most places by 5 to 40 feet of reddish-pink to buff colored granite residuum, which contains a few boulders of exfoliation. The rock body is moderately sheared, but only two prominent planes of jointing were detected. The strikes of these joints were measured as N. and N. 65° E. Evidence of shear is especially prevalent in the rocks forming the west perimeter of the roughly circular pit quarry, the granite appearing badly mashed and broken and the joint systems hardly detectable. (For quarry type, see page 50.)

The rock is a medium-grained, pinkish-gray granite, containing abundant orthoclase, smoky quartz, and minor amounts of biotite and pyrite. In some places in the quarry, notably the highly sheared parts, a thin veneer of epidote coats the joint surfaces and in some instances replaces the pink feldspar. Many intergrowths of orthoclase and quartz can be seen in a hand specimen of the rock. This renders toughness to the rock, making it an excellent crushed product for road surfacing and concrete aggregate. Results of Los Angeles abrasion tests on the stone are shown in Table III, page 55. A petrographic analysis of granite from the Neverson Quarry by the U. S. Bureau of Public Roads shows the following minerals and their percentages:

Quartz	39%
Orthoclase	55%
Biotite	4%
Calcite	1%
Apatite	0.6%
Muscovite	0.4%

According to this thin-section analysis, the Neverson Quarry rock is a normal or biotite granite, which has been subjected to mineral enrichment by thermal waters or normal near-surface ground waters. The alteration is made apparent by the presence of calcite, a mineral not associated with the crystallization of silicic magmas. The pyrite and epidote are also of secondary origin.

The Neverson Quarry was first opened in 1917 for the production of road metal and jetty stone and continued in operation until it was closed in 1927. Production was resumed for about one year between 1938 and 1939, but the quarry was closed again and was not reopened until 1940, from which time production has continued and enlarged to the present day. The principal products from the quarry, in order of general importance, are concrete aggregate, road metal, and railroad ballast. Crushed material from the quarry is shipped by rail to many cities in the Coastal Plain and is reported to be a chief source of stone received in Norfolk, Virginia.

ELM CITY AREA

The Elm City granite area includes about 15 to 20 acres of boulder outcrops and nearly flat surface masses of granite, two miles NNE. of the town of Elm City and along the Atlantic Coast Line Railroad. In the approximate center of the area of outcrop, quarrying of the granite has been carried on intermittently for almost a hundred years. The extereme toughness and apparent hardness of granite from this deposit dismisses it from consideration as an economically available source either of crushed or dimension stone. No quarrying has been done at the locality in more than 30 years; however, in the past the quarry furnished crushed stone to Coastal-Plain cities in North Carolina. The quarry area covers approximately 400 by 600 feet and is reported to be more than 30 feet in depth. It is partially filled with water. Fresh granite lies below 1 to 30 feet of reddish-tan, clayey residuum, below which exfoliation of the granite is common. The massive rock is cut by two prominent but widely spaced sets of joints, striking N. 75° W. and N. 40° E., and in many places the open fractures have been filled with quartz, coarse feldspathic material, or greenish schistose dike material composed largely of amphibole and quartz. Small cubes of pyrite are disseminated through the dike material and the granite. The unfilled joints and fractures are slickensided, and in some places a thin coating of a yellowish-green mineral, probably damourite (hydro-muscovite), is present on the surfaces.

The rock is light pinkish-gray, medium-grained, and is composed of closely interlocked grains of quartz and feldspar and a little biotite. The principal accessory minerals include zircon, apatite, ilmenite, and

titanite. The stone is very hard and is reported to possess poor working qualities. A thin section of the granite is described by Watson and Laney, as follows:

> ". . . a biotite granite . . . scattered occasional and partially idiomorphic crystals of compact hornblende. Feldspar preponderates and is composed of the potash varieties with much striated acid plagioclase . . . of the composition $Ab_{12}An_1$. The feldspars are clouded from slight alteration into kaolin and muscovite . . . Quartz forms distinct areas of an interlocking mosaic of smaller grains than the feldspar through which are scattered occasional feldspar grains and biotite. Biotite is altered to chlorite."

From the above description, which lacks definite percentage relations, the rock probably should be placed in the type previously defined as granodiorite; the rock, however, may represent an example of quartz-monzonite.

EDGECOMBE AND NASH COUNTIES

In only a small area in Edgecombe County, located near the Nash County line, do granite and older rocks crop out above the Coastal-Plain sediments. To the west, in Nash County, granite and volcanic slates occupy the entire area with the exception of two narrow strips of sediments to the north and south, respectively, in the eastern portion of the county. Nash County is discussed with the Coastal-Plain counties because of the relation and continuity of the outcrops, beginning in western Edgecombe County and continuing westward along the Tar River into Nash. Large boulder outcrops of granite first appear about one-half mile north of Rocky Mount, in Edgecombe County along U. S. Highway 301, continue northward for approximately one-half mile, and are best exposed on both sides of the Tar River near the junction of N. C. Highway 43 and Highway 301. Westward from this junction, the granite is traced for several miles into Nash County by small boulder or flat-surface outcrops. The exposures in the area described merit investigation as a possible source of stone for crushing. In this area, granite has intruded schist and gneiss. The outcrops of granite in the river and along its banks near the highway junction were examined and found to consist of pink and gray feldspar, quartz, and fine books of biotite. The texture of the granite varies from fine to large and to porphyritic, but in all size phases the rock is even-granular and is a light pinkish-gray. Segregations of quartz are present in some of the outcrops. The outcrops are generally fresh and firm, though some of the boulder-like exposures show exfoliation. Four sets of joints, cutting the rock into blocks of various sizes, strike N., N. 40° E., N. 30° W., and N. 75° W. and in some places are very closely spaced. Vein material, consisting of quartz and fine-grained pegmatite, occupies some of the joints. The following petrographic description of the stone was taken from the Watson and Laney report:

> ". . . closely interlocked aggregate of feldspar, quartz, and biotite. Orthoclase and microcline have about equal distribution through the section with but little plagioclase indicated. . . . Biotite . . . is partly altered to chlorite. . . . A few scattered grains of black iron oxide and inclusions of prismatic apatite and zircon complete the list of minerals in the rock."

The rock is a normal or biotite granite.

PITT COUNTY

With the exception of a small area near Fountain in the extreme western portion, where granite gneiss is exposed, Pitt County is covered entirely by Coastal-Plain sediments. The occurrence of granite in Pitt County is discussed briefly here because it represents the easternmost appearance in the Coastal Plain of a granite or related rock, not because of any particular commercial possibilities offered by the rock.

FOUNTAIN AREA

The area of outcrop lies just outside the southern corporate limits of Fountain and consist of 2 or 3 acres of nearly flat surface outcrops of a gneissoid rock of granitic composition. The unweathered rock is an extremely tough (hard), massive granite, containing dark-colored gneissic inclusions and a few widely spaced, mineral-filled joints, which strike approximately N. and E. The joints are filled with one- to two-inch veins of milky quartz, containing in some places a little feldspar. The inclusions range from one-fourth of an inch to more than 2 feet across and are quite prevalent in some parts of the deposit. The residual overburden consists of about two inches of yellowish-brown, gritty clay. Bottom joints in the rock are well devel-

oped and cut the deposits into sheets 6 to 18 inches in thickness. A small amount of dimension stone was removed from this deposit for local use as late as 1938, and it is reported to work very poorly and with great difficulty. Although the stone is a pleasing light gray color, it is doubtful that it will be of commercial use because of the extreme toughness and lack of workability.

Megascopically, the rock is a highly siliceous, medium-grained granite-gneiss, containing quartz, feldspar, biotite, and iron oxide. A thin section of the rock shows the following mineral composition:

Quartz	36%
Orthoclase (much microcline)	47%
Plagioclase	5%
Biotite hornblende	9%
Other (magnetite, apatite, chlorite, calcite)	3%

According to the analysis, this stone falls into the gneissic-granite class as previously defined.

ANSON AND RICHMOND COUNTIES

THE WADESBORO-ROCKINGHAM AREA

The Wadesboro-Rockingham granite area extends from about two miles west of Rockingham, in Richmond County, westward to within three miles of Wadesboro, in Anson County. Although outcrops of fresh granite are rather rare, the presence of extensive deposits lying beneath granite residuum is recognized by the color and partially decayed mineral components of the residual material. In many places Coastal-Plain sediments overlie the granite or its disintegrated product, but in general these deposits are spotty.

Granite showing the least degree of weathering is exposed best along and immediately south of the Seaboard Air Line Railroad, beginning about 2.5 miles west of Rockingham and appearing in the deeper cuts almost to Wadesboro. In some of the cuts, the granite is essentially fresh, while in others the effects of weathering have rendered the rock unsuitable for commercial use. Other exposures of interest can be seen in the deeper cuts along U. S. Highway 74, west of Rockingham, and in the vicinity of Lilesville and Bonsal, about 4 miles east of Wadesboro. These exposures are moderately to strongly weathered and appear as bed-like ledges on both sides of the highway. Complete decay has progressed to great depth along the fractures cutting the deposit and to an overall depth of about 15 feet in the massive portions of the deposit. Fresh outcrops of granite appear over a rather extensive area south of the railroad and west of the Pee Dee River. Irregular patches of Coastal-Plain sediments cover the granite in many parts of this area; however, boulders and ledge-like and flat-surface masses of granite are quite numerous in other locales within the same area. Prominent flat-surface and boulder outcrops of fresh granite can be seen along U. S. Highway 52, beginning about 2 miles south of Wadesboro. Jointed structure is well developed in the granite exposures of the area and is generally spaced so as to subdivide the deposit into blocks of large dimension. Measurements of the joints show the following strikes: Bonsal area, N. 70° E., N. 20° W., and N.; south of Wadesboro, N. 30° E. and N. 60° W.

The granite in the Wadesboro-Rockingham area is fairly uniform both in texture and color, generally being of large to porphyritic texture and ranging in color from pinkish gray to light pink. Most color and textural combinations produce a pleasing appearance. In none of the outcrop areas visited was a medium-grained granite found. In the porphyritic phase, the rock is composed of grains of biotite up to one-fourth of an inch across, quartz grains up to three-fourths of an inch across, and feldspars, some of which show idiomorphic crystal outline, up to one and one-fourth inches across. In the large-grained phases of the rock, the quartz and feldspar grains are about equal in size and the biotite, about half as large. It is interesting to note the presence of subrounded quartz grains in some of the outcrops of large-grained granite, their presence being especially pronounced in the highly weathered, friable zones. The rocks containing the subrounded quartz grains noticeably lack idiomorphic feldspars.

A moderately weathered hand specimen of large-grained material taken from an exposure along U. S. Highway 74 near Bonsal has the following mineral composition:

Orthoclase	30%
Plagioclase	25%
Quartz	25%
Biotite	20%

A microscopic examination by Watson and Laney of a specimen taken near Rockingham shows the following characteristics:

> ". . . an aggregate of quartz and feldspar with considerable biotite. Potash feldspars with nearly equal or greater proportion of plagioclase make up the feldspathic constituent, which shows some alteration. . . . A few scattered grains of magnetite are distributed through the section. . . ."

On the basis of the incomplete petrographic analysis, the rock of the area should be classified quartz-monzonite.

In general, the thick residual material overlying the granite deposits in the Wadesboro-Rockingham area, coupled with the availability of gravel from the Coastal-Plain formations, has to a large extent discouraged the commercial production of granite. This is espescially true in regard to a crushed-stone industry, which would be unable to compete with natural gravel production in the area. In most localities the initial depth to fresh rock generally constitutes a stripping problem likely to prevent the utilization of the granite for dimension stone; but, despite this problem, the fresh granite is of a good quality and pleasing appearance and merits investigation in some areas as a potential source of stone for this purpose. Production in the area has been limited to several small openings near Rockingham for the quarrying of stone for local use early in the century. No production is reported from either Anson County or Richmond County at present.

BASIC ROCKS

The granitic rocks within the Wadesboro-Rockingham area are the first in the granite areas of the State to show large-scale penetration by basic-rock dikes of either a diabasic texture or schistose structure. As will be noted later, dikes of this character are quite prevalent in the Piedmont section of the State but up to this point are found sparingly on the Coastal Plain. The largest of the dikes in the area is exposed in the western part of Rockingham, near the old Great Falls Cotton Mills building on U. S. Highway 74. The dike rock is a hard, dense, diabase-like rock, containing much epidote, which imparts a greenish color to the rock, and large irregular areas of quartz. According to Watson and Laney, the dike is more than a hundred feet wide, strikes about N., and is referred to as a greenstone-diabase dike. Although the Rockingham dike is the largest, it is only one of many which outcrop in the area. All are diabasic or schistose and strike north or a few degrees west of north.

GRANITES OF THE PIEDMONT PLATEAU

The Piedmont Plateau in North Carolina, lying between the Coastal Plain and the Blue Ridge, is second in size among the geographic divisions of the State but contains approximately 95 percent of the commercial granite deposits. The granites in this province have been utilized more or less in both domestic and large-scale commercial production for more than a hundred years, and the dimension granites from this region have, since 1900, been well known throughout the United States and other parts of the world as superior quality monumental and building stone. As shown on Plate I, the Piedmont region comprises three distinct granite areas: the Northeast Piedmont, the Central Piedmont, and the Western Piedmont.

Northeast Piedmont: The rocks of the northeastern part of the Piedmont Plateau include several belts of granitic rocks, separated by gneisses, schists, and volcanic slates. The granite deposits of the Northeast Piedmont rank second in volume but last in value of the commercial stone produced in the Piedmont.

Central Piedmont: The Central Piedmont includes the largest body of granitic rocks in the entire State, along with the main belt of the Volcanic-Slate Series and a narrow band of gneisses and schists, all of which trend northeast across the State. The granite and related rocks—quartz-monzonite, granodiorite, syenite, diorite, and gabbro—occurring in the Central Piedmont comprise the most valuable commercial rock deposits in North Carolina.

Western Piedmont: The Western Piedmont division of the State is underlain largely by gneisses and schists, though in certain localities granite has penetrated the older material and outcrops in northeast trending belts. In much of the region the granites are gneissic. In volume of commercial granite, the West-

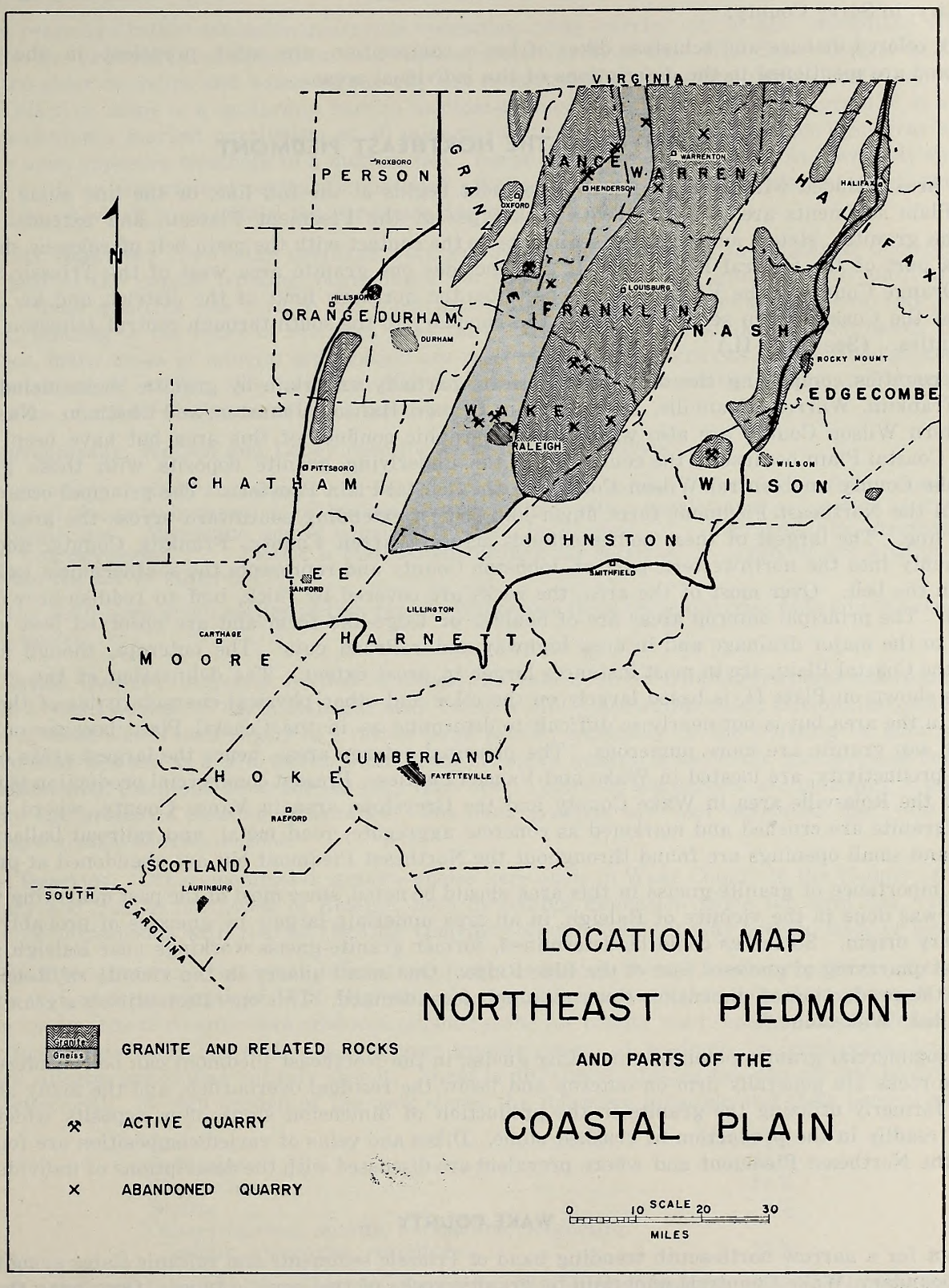
VIRGINIA
PERSON
ROXBORO
GRANVILLE
VANCE
WARREN
WARRENTON
HENDERSON
OXFORD
HALIFAX
N
ORANGE
DURHAM
HILLSBORO
LOUISBURG
FRANKLIN
NASH
ROCKY MOUNT
EDGECOMBE
WAKE
RALEIGH
PITTSBORO
CHATHAM
WILSON
JOHNSTON
SMITHFIELD
LEE
SANFORD
LILLINGTON
CARTHAGE
HARNETT
MOORE
CUMBERLAND
FAYETTEVILLE
HOKE
RAEFORD
SCOTLAND
LAURINBURG
SOUTH CAROLINA
LOCATION MAP
NORTHEAST PIEDMONT
AND PARTS OF THE
COASTAL PLAIN
Granite Gneiss
GRANITE AND RELATED ROCKS
ACTIVE QUARRY
ABANDONED QUARRY
0 10 SCALE 20 30
MILES

PLATE II

ern Piedmont ranks third; in production, however, it is second, due to the extensive quarrying operations at Mt. Airy, in Surry County.

Dark colored diabase and schistose dikes of basic composition are most prevalent in the Piedmont Plateau and are mentioned in the descriptions of the individual areas.

GRANITES OF THE NORTHEAST PIEDMONT

The area included within the Northeast Piedmont begins at the fall line, or the line along which the Coastal-Plain sediments are in contact with rock types of the Piedmont Plateau, and extends westward across the granites, slates, and Triassic sediments to the contact with the main belt of volcanic slates, comprising a part of the Central Piedmont. It also includes one granite area west of the Triassic-Slate contact in Orange County. The Virginia line constitutes the northern limit of the district, and an inland extension of the Coastal-Plain sediments forms the boundary to the south through central Johnston and Harnett Counties. (See Plate II.)

The counties comprising the division which are partially underlain by granitic rocks include: Wake, Vance, Franklin, Warren, Granville, Northampton, Orange, Halifax, Johnston, and Chatham. Nash County and western Wilson County are also within the geographic confines of this area but have been discussed with the Coastal Plain because of the continuity of the underlying granite deposits with those present in Edgecombe County and central Wilson County in the Coastal Plain Province. The principal occurrences of granite in the Northeast Piedmont form finger-like bodies, extending southward across the area from the Virginia line. The largest of these bodies extends across Warren County, Franklin County, and eastern Wake County into the northwestern part of Johnston County and represents the southernmost extension of granite in the belt. Over most of the area, the rocks are covered by thick, buff to reddish-brown, granite residuum. The principal outcrop areas are of boulder or ledge-like form and are observed best along and adjacent to the major drainage and in deep highway and railroad cuts. The outcrops, though similar to those of the Coastal Plain, are in most instances larger in areal extent. The delineation of the granite deposits, as shown on Plate II, is based largely on the color and other physical characteristics of the residual material in the area but is not nearly so difficult to determine as in the Coastal Plain because outcrops of fresh and sap granite are more numerous. The principal outcrop areas, hence the largest areas of present and past productivity, are located in Wake and Vance Counties. Present commercial production is restricted largely to the Rolesville area in Wake County and the Greystone area in Vance County, where large tonnages of granite are crushed and marketed as concrete aggregate, road metal, and railroad ballast. Other quarries and small openings are found throughout the Northeast Piedmont but are abandoned at present.

The importance of granite-gneiss in this area should be noted, since most of the past quarrying for building stone was done in the vicinity of Raleigh, in an area underlain largely by gneisses of probably primary sedimentary origin. So far as could be determined, former granite-gneiss workings near Raleigh represent the largest quarrying of gneisses east of the Blue Ridge. One small quarry in the vicinity of Raleigh is engaged in the production of dimension stone to supply local demand. This operation utilizes a granite-gneiss, locally called "Wakestone."

The commercial granite potential, including gneiss, in the Northeast Piedmont can be considered unlimited. The rocks are generally firm on outcrop and below the residual overburden, and the many abandoned openings formerly utilizing the granite in the production of dimension stone offer deposits which can be expanded readily in the production of crushed stone. Dikes and veins of varied composition are found in all parts of the Northeast Piedmont and where prevalent are discussed with the descriptions of individual areas.

WAKE COUNTY

Except for a narrow north-south trending band of Triassic sediments and volcanic slates along the westernmost boundary, Wake County is underlain by granitic rocks of two genetic types. Occupying the eastern and east-central part of the county are true plutonic rocks largely of granitic composition and medium-grained texture. Granite-gneiss and micaceous schist underlie the remainder of the county west of the granite belt, beginning along a line passing approximately 2 miles east of Raleigh. (See Plate II.)

RALEIGH GRANITE AREA

Many years ago rather extensive quarrying operations were carried on in the immediate vicinity of Raleigh for the production of dimension and crushed stone for local use. The State Capitol building and many of the older churches and homes of the city are constructed of a granite-gneiss, locally called "Wakestone." This type stone is a uniformly fine- to medium-grained rock of approximate granitic composition, usually displaying a marked parallelism of all mineral constituents. Colors range from light gray to grayish tan, which upon exposure weathers to a mottled tan. Large blocks of the stone almost inevitably show penetration by aplite or fine-grained pegmatitic material. Wakestone was formerly obtained from three large quarries, two of which were within the corporate limits of Raleigh.

The City Quarries: Two large openings were worked in the vicinity of the National Cemetery, about 1.5 miles east of the Capitol building, beginning about 1833 and continuing intermittently until after 1903. Stone from these quarries was used in the construction of the State Capitol buiding. According to Watson and Laney, jointing in the rocks of this area is at fairly close intervals and strikes approximately E. Within the quarries, many areas of mineral segregation are present and usually occur as vein-like bodies, conforming to an approximate N. strike. The vein and dike materials consist of pegmatite, aplite, and quartz, and all show evidence of minor displacement since intrusion.

Petrographically, Watson and Laney describe Wakestone, as follows:

> ". . . in order of their abundance . . . feldspar, quartz and biotite. The feldspathic constituent consists of the potash varieties, orthoclase and microcline, with a nearly equal proportion of striated acid plagioclase. Microcline nearly equals orthoclase in amount. . . . micropoikilitic structure is fairly well developed. . . . Biotite is distributed through the sections. . . . Zircon and apatite . . . complete the list of minerals."

Based on the definitions given earlier in this report, Wakestone from these quarries falls into the class quartz-monzonite gneiss.

The Sutton Quarry: A recent revival of interest in Wakestone for building purposes has resulted in the opening of a small quarry in north Raleigh, near Lassiter Mill. According to Mr. Sutton, the owner, dimension stone of small size is used locally to a rather large extent, especially in the building or enlargement of schools and churches and as a trim stone. Stone from the small quarry is decidedly gneissic and corresponds in composition with the stone from the old City Quarries. Colors in the deposit are generally a gray-tan to mottled tan and present a pleasing appearance. The joint systems are well developed, but vein and dike materials are almost entirely absent.

Other Quarries: Other openings in granite-gneiss were made in Wake County in the vicinity of the State Penitentiary and 2 miles northwest of Raleigh, both furnishing dimension stone for local use. In general, the rock type corresponds with that of the City Quarries, though locally it may become more or less gneissic.

The Crabtree Quarry: This small bench-type quarry is located about 3.5 miles northwest of the Raleigh city limits, 0.75 of a mile south of U. S. Highway 70, and adjacent to Crabtree Creek. Although now abandoned, the quarry has in recent years produced crushed stone for county road repairs and remains in excellent condition for further use. The rock is a light gray granite-gneiss of medium- to large-grained texture, in which dark silicates are almost entirely absent. Shear is prominent, cutting the deposit into blocks of small, irregular dimension. A thin section of the rock shows the following minerals and their percentages:

Quartz	32%
Orthoclase	35%
Plagioclase	10%
Biotite	8%
Others (zircon, apatite, tourmaline, magnetite, calcite, muscovite, sericite)	15%

Accordingly, the rock falls into the class granite-gneiss. Significant features observed in the thin section were: (1) numerous tangential grain contacts, which constitute the most prominent microscopic characteristic of the rock, (2) the presence of considerable sericite, formed by the alteration of the feldspar constituents, (3) the abundance of accessory minerals, and (4) fine mosaics of quartz filling the interstitial

areas in the rock. Within the quarry, numerous small mineral veins, consisting of siderite(?), biotite, and muscovite, can be found occupying open joints and planes of shear, while other joint surfaces are coated with muscovite and radiated tourmaline crystals.

ROLESVILLE GRANITE AREA

Dimension Stone Quarry: The quarry is located about 50 feet east of the Rolesville School and within the southern limits of the community of Rolesville, in northeast Wake County. It is accessible by N. C. Highway 59. The deposit in which the bench-type quarry is developed outcrops in a gently dipping dome-like manner over approximately 1500 square feet. A considerable amount of dimension stone has been produced at this quarry, and though now abandoned it remains in an excellent condition for further operation. The rock is essentially massive, with only two directions of jointing noted over the entire area of outcrop. It is a light gray to pinkish-gray granite of uniform medium grain and is essentially unweathered throughout. In some places, the segregation of biotite interrupts the uniformity of texture, and many thin veins of binary granite cut the deposit along a northeast strike, which seemingly conforms to the strike of joints, N. 26° E. and E. Sheeting in the granite is well developed, permitting the quarrying of blocks of a uniform thicksnes of about five feet. Iron oxide stain is prevalent in some parts of the quarry. A thin section of the rock shows the following mineral percentages:

Quartz	30%
Orthoclase and microcline	34%
Plagioclase	28%
Biotite	7%
Others (chlorite, sericite, apatite)	1%

On the basis of this examination, the rock falls into the class quartz-monzonite.

Lassiter Quarry: The Lassiter Quarry, located about one mile southeast of Rolesville, is the largest and among the most efficient crushed-stone operations in North Carolina. (Figure 1.) According to Mr. H. S. Satterwhite of the Bryan Rock and Sand Company, the quarry was first opened in 1922 and engaged exclusively in the production of street curbing until 1923, at which time crushing facilities were installed at the quarry. From 1924 to 1929, the principal products from the quarry were curbing, paving blocks, and crushed stone. During this period, curbing and paving blocks were shipped to points as distant as Philadelphia. Operation of the quarry was intermittent during the years 1929 to 1941, but it has since been operated on a full-time basis with the most modern equipment in all phases of the quarrying operation. The principal products include concrete aggregate, road metal, and railroad ballast. Markets are supplied in North Carolina, Virginia, South Carolina, Georgia, and Florida. A large amount of stone from the quarry is marketed in Coastal-Plain cities of the State. At the present time, the quarry covers approximately half a square mile and averages more than 75 feet in depth. It is a pit-type opening, although the east end presents a reasonably accessible entrance to the quarry. Overburden in the quarry area is negligible.

The granite utilized by the quarrying operation at Rolesville varies from a light pinkish gray to a medium gray, even-granular, medium-textured rock, which in some places shows a slight coarsely foliated character, to a medium-grained, massive, white granite containing a small amount of biotite. Though variable in amount, the biotite is always evenly distributed. A thin-section analysis of the granite by the U. S. Bureau of Public Roads shows the following composition:

Quartz	36%
Orthoclase	51%
Microcline	2%
Biotite	11%

According to the analysis, the granite of the Lassiter Quarry is a normal or biotite granite.

WENDELL GRANITE AREA

The principal occurrence of granitic rock in the Wendell area is about one mile east of the corporate limits of the town, in the eastern part of Wake County. A large quarry, Rockton Quarry, formerly operated by the Bryan Rock and Sand Company, has been developed in this vicinity in a rather pronounced dome-like body

FIGURE 1. LASSITER QUARRY, ROLESVILLE, WAKE COUNTY
(Courtesy Aero-Pix, Raleigh)

of granitic rock covering about 100 acres. The quarry is about 500 feet square and was worked to an average depth of about 125 feet, beginning on a flat surface and expanding vertically and horizontally. Because of increased production at the company's Lassiter Quarry, this operation was abandoned about 5 years ago, and the quarry is now filled with water to a depth of about 50 feet. Prior to cessation of operation, the quarry furnished large amounts of crushed stone for use as concrete aggregate, road metal, and railroad ballast to Eastern North Carolina.

The granite is light gray to pinkish gray and ranges in texture from even-granular, medium-grained rock to a distinctly porphyritic phase, in which half-inch to one-inch laths of plagioclase are the principal mineral constituent. Large segregations of biotite and quartz are commonly found in the medium-textured phase, which is richer in the two minerals than the highly feldspathic porphyritic parts of the deposit. The rock is moderately sheared, with the most prominent plane of jointing having a strike of N. 60° E. Most of the open fractures are coated with a thin veneer of biotite, and quartz and binary granite veins cutting the granite are common. Sheeting within the deposit is very irregular and because of shear, hardly detectable. At some places, buff to reddish-brown residuum covering the granite attains a thickness of 30 feet. A microscopic examination of several thin sections, cut from the medium-grained phase of the granite and reported by the U. S. Bureau of Public Roads, shows the following minerals and their percentages in the rock:

Quartz	32% to 42%
Orthoclase	34% to 49%
Plagioclase	0% to 21%
Microcline	1% to 11%
Perthite	2% to 5%
Biotite	0% to 8%
Muscovite	0% to 3%

The results of these analyses place the rock in the category of biotite granite, although one of the analyses shows a rock approaching quartz-monzonite.

KNIGHTDALE GRANITE AREA

The Knightdale granite area is located in southern Wake County, about 6.5 miles west of Wendell. The largest outcrops occur as low, flat-surface masses and large spheroidal boulders. The granite is very similar to that occurring in the Rolesville area, though the mineral composition appears more uniform.

Abandoned Quarry: An abandoned quarry, covering approximately 1.5 acres, is located 1.5 miles east of the corporate limits of Knightdale and 0.1 of a mile north of the Norfolk Southern Railway. It is accessible by hard-surfaced road and a quarry road from Knightdale. According to local inhabitants, the quarry has produced dimension stone but more recently was a source of rock for crushing. It is reported to have been operated for about one month in 1950 in the production of crushed stone in small amounts. The quarry is now filled almost to the surface with water, and the depth of the quarry could not be determined.

The granite is a uniformly light gray to pinkish-gray, even-granular rock of medium texture. Biotite is evenly distributed through the rock, and occasional quarter-inch laths of plagioclase, which nearly equals in amount the orthoclase constituent, can be seen in hand specimens of the granite. The rock body is cut by widely spaced vertical joints and rarely by veins of pinkish binary granite. The stone is well suited for use as small dimension stones and crushed material and is unweathered on the exposed surface.

OTHER GRANITE AND GRANITE-GNEISS AREAS IN WAKE COUNTY

Other areas of granite and granite-gneiss outcrops in Wake County can be found in the vicinity of the following communities:

1. Zebulon: Granite of a type similar to that at the Rockton Quarry near Wendell occurs near Zebulon, and large flat-surface outcrops can be seen adjacent to U. S. Highway 264, southeast of Zebulon, in the eastern part of Wake County.

2. Wake Forest: Granite of a type similar to the Rolesville stone outcrops rather extensively in the vicinity of Wake Forest, in northern Wake County.

3. Falls: Granite-gneiss, or Wakestone, crops out near the village of Falls, in north-central Wake County.

VANCE COUNTY

A large body of granitic rock underlies the central part of Vance County, being intrusive into the volcanic slates in the western part of the county and gneisses and schists in the eastern portion of the county. (See Plate II.) The area of present commercial granite production in Vance County is located at Greystone; however, a considerable amount of dimension granite was produced some years ago about three miles northeast of Greystone, in the vicinity of Middleburg.

GREYSTONE QUARRY

The present Greystone Quarry, located along the Seaboard Air Line Railroad in east-central Vance County, is one of three openings made in the granite near the village of Greystone, the first of which was begun about 1885. In 1904, the quarry now in operation was about 100 feet square and had been worked to an average depth of less than 12 feet. This compares with an average depth of approximately 150 feet and an areal extent of 1,000 by 700 feet at the present time. This quarry has been in almost continuous operation since about 1900 and for many years furnished curbing, paving block, and crushed stone to cities as distant as Norfolk, Virginia. Crushed stone from the quarry is still marketed in Norfolk. Present production is limited to crushed aggregate, road metal, and railroad ballast. Ballast is shipped to points as distant as Florida, and other crushed products are marketed in Coastal-Plain cities in North Carolina as far east as Greenville.

The granite, covered by 1 to 6 feet of buff colored residuum, is moderately gneissic, showing a rough parallel growth of the biotite constituent and is light pinkish gray in color. Segregations of biotite in the granite are common, and a thin veneer of the same mineral occurs on many of the open-joint surfaces. Many granitic and fine-grained pegmatitic dikes and veins penetrate the rock and the principal joints, which strike N. 60° E. and N. 5° E. The rock is consistently medium grained, though occasional large grains of orthoclase tend to disturb the textural uniformity. A thin section prepared from a specimen of the rock shows the following mineral composition:

Quartz	39%
Orthoclase	50%
Plagioclase (oligoclase)	2%
Biotite	6%
Others (apatite, zircon, magnetite, muscovite, chlorite)	3%

Accordingly, the rock falls into the class biotite granite. Of interest in the examination of this section was the extensive kaolinization of feldspars, the extensive chloritization of the biotite, and the considerable amount of muscovite and sericite, also derived from the alteration of the feldspar constituent. In addition, many quartz-feldspar intergrowths were observed.

MIDDLEBURG QUARRY

About three miles north of Greystone and one mile west of the village of Middleburg, in east-central Vance County, two large quarries were opened about 1900 and were operated on a small scale for many years, furnishing paving block and curbing to cities in Southeast Virginia.

The granite from these quarries is remarkably similar in mineral composition to the granite at Greystone, though it is distinctly more gneissic and is darker in color as a result of an increase in the amount of biotite present. As in the Greystone granite, occasional outsized grains of orthoclase and segregations of biotite tend to disturb its medium texture. Only one plane of jointing, having a strike of N. 87° E., cuts the massive, flat-surface deposit, but binary granite dikes and quartz veins are found in all parts of the quarry area. The granite dikes range in thickness from a feather edge to one-half inch, but the quartz veins are rather uniformly about one inch in width. Residual overburden in the quarry area is negligible.

The Middleburg granite is not well suited for any type dimension stone with the exception of rough curbing, and it is doubtful that the deposit at the old quarries could be utilized economically as crushed stone because of the massive character of the granite.

OTHER GRANITE AREAS IN VANCE COUNTY

Other areas in Vance County in which granite outcrops are extensive are located along U. S. Highway 1, north of Henderson and in the vicinity of Williamsboro, located about 10 miles northwest of Henderson. According to a microscopic examination by Watson and Laney, the granitic rock which crops out near Henderson is a normal or biotite granite, showing a slight gneissic structure.

FRANKLIN COUNTY

Large boulder outcrops and flat-surface masses of granitic rock are rather numerous over the central and eastern portions of Franklin County and are especially notable in the vicinity of Louisburg, the county seat. To the west of Louisburg, along the county line, gneisses and schists similar to the rocks in western Wake County underlie a generally thick residual cover. A small part of northeast Franklin County is underlain by rocks of the Volcanic-Slate Series. (See Plate II.) The commercial utilization of granitic rocks has never been undertaken in Franklin County, though some areas appear to be worthy of commercial development.

THE LOUISBURG AREA

During the investigation, numerous outcrops of relatively fresh granite were observed in the vicinity of Louisburg, especially along the Tar River and N. C. Highway 56 between Louisburg and Franklinton. A thin section, cut from a specimen of the granite exposed along the Tar River in Louisburg, is described by Watson and Laney, as follows:

> ". . . a medium texture biotite granite, composed of . . . orthoclase, microcline, acid plagioclase, quartz, biotite, muscovite, apatite, zircon, iron oxide, chlorite and kaolin. Orthoclase is the predominant feldspar with but little microcline. . . ."

According to this analysis, the rock is interpreted as representing a medium-grained biotite granite. A specimen of the granite collected by the author shows it to be a light gray massive granite of uniform medium texture, containing no parallelism of mineral constituents. The deposit, located near the center of Louisburg, is cut into blocks of varying dimensions by joints, striking N. 75° W. and N. 20° W. Quartz veins occupy some of the joints and binary granite dikes up to 6 inches in width cut the deposit in many directions. A specimen of granite obtained from an outcrop along the State highway between Louisburg and Franklinton is very similar to the Louisburg granite.

Dimension Stone Quarry: Approximately 12 miles west of Louisburg, near the county line, a small opening was made many years ago in a distinctly gneissic rock similar to the granite-gneiss in Wake County. The opening is about 75 feet in diameter and was worked to an average depth of about 12 feet. The small flat-surface outcrop in which the opening was made is cut by joints, striking N. 61° W. and N. 19° E., and many of the joints are filled with vein quartz. The stone is light gray to mottled tan in color and of a grain size intermediate between fine and medium. Its gneissic character is immediately apparent upon examination of hand specimens, and in appearance it is as desirable a stone for building purposes as the Wakestone of the Raleigh area of Wake County. Apparently, this quarry was worked many years ago for blocks of small dimensions for local building purposes. A thin section cut from a specimen of the granite-gneiss shows the following mineral composition:

Quartz	38%
Orthoclase	57%
Biotite	4%
Others (apatite, chlorite, epidote, titanite)	1%

The rock falls into the class herein defined as granite-gneiss. Of considerable interest in the examination of the thin section were the numerous tangential contacts between quartz grains and the overall "quartzitic" appearance of the stone in the areas containing few or no dark silicates. The close proximity of the rock from this quarry to the schist-gneiss and granite contact, coupled with the microscopic properties, suggest a non-plutonic origin for the rock.

BASIC DIKES

Massive diabase dikes of gabbroic composition are found in many places in Franklin County penetrating the granitic rock but seem especially prevalent along the highway between Louisburg and Franklinton. These intrusives are typical of the diabase dikes which occur in many parts of North Carolina from the granite areas of the Coastal Plain to the Blue Ridge. They are composed predominantly of plagioclase (labradorite), augite, olivine, with magnetite as the principal accessory mineral. The average strike of the dikes between Louisburg and Franklinton is roughly N. 40° W.

WARREN COUNTY

Granitic rocks are exposed in only a few places in Warren County, the principal areas being located around Warrenton, in the east-central portion of the county, and in the vicinity of Warren Plains, about 3 miles to the north. Although approximately three-fourths of the county is underlain by granitic rock, residual overburden attains great thickness over most of the county and accounts for the scarcity of outcrops. So far as could be determined, there has been no commercial granite production in Warren County. (See Plate II.)

WARRENTON AREA

The granite outcrops in the vicinity of Warrenton are uniformly medium grained, light gray in color, and in most of the exposures the rock is very slightly gneissic. Joints cutting the granite strike N. 30° W. and N. 50° to 60° E. A small quarry was opened in the granite in the west corporate limits of Warrenton many years ago to furnish crushed material for improving the streets of the town but has been abandoned. A thin section prepared from a specimen of this granite is described by Watson and Laney:

> ". . . a thin section of the rock reveals a . . . biotite-hornblende gneiss. . . . Besides biotite and hornblende, the principal minerals in the rock are orthoclase, with an equal or greater amount of striated plagioclase, quartz, epidote, and chlorite. Microcline entirely fails. The hornblende nearly equals biotite in amount. . . . Quartz is equal to or greater in amount than the feldspathic constituent."

According to this analysis, the rock should be placed in the class quartz-monzonite.

WARREN PLAINS AREA

Granite similar in composition to that found in the Warrenton area outcrops about 3 miles north of Warren Plains and, like the granite at Warrenton, has never been utilized commercially. In some phases of the rock, almandite(?) garnet becomes a prominent accessory mineral.

Warren County State Quarry: In recent years the State Highway and Public Works Commission has developed a quarry in a light gray, fine- to medium-grained granite in southwestern Warren County, 6.5 miles southwest of Warrenton, in the vicinity of the village of Afton. This granite deposit outcrops as a prominent dome-like body, standing about 75 feet above an adjacent creek. It is intricately jointed and intruded by vein quartz. The joints strike N. 69° E., N. 44° W., and N. 17° W. Sheeting in the granite is poorly developed. The presently abandoned quarry is typical of the small bench-type quarry developed in many places across the State by the State Highway and Public Works Commission. It covers about one-half acre.

The granite is an even-granular massive rock, showing a uniform distribution of biotite through most of the deposit; however, large prominent segregations of the biotite up to 6 inches across are found in some places within the quarry. Many of the biotite segregations are crumpled and mashed to such an extent as to render them gneissic. A thin section of the stone from the quarry shows the following mineral composition:

Quartz	32%
Orthoclase	47%
Plagioclase	13%
Biotite	7%
Others (muscovite-sericite, zircon, magnetite)	1%

The rock is a biotite granite. Interlocking quartz and feldspar grains and peripheral shattering of the quartz constitute the most pronounced microscopic characteristics of the rock.

Old Quarry: An abandoned quarry near the village of Oline, about 6.75 miles northeast of Warrenton, was visited briefly during the Warren County investigation. The granite from this quarry is very similar in appearance to the rock utilized at the State quarry near Afton, though it shows a very slight coarse foliation. As in the Afton deposit, this rock is highly jointed and intruded by vein quartz.

GRANVILLE COUNTY

The occurrence of granitic rocks in Granville County is limited to the east-central portion of the county, beginning at the Virginia state line on the north and terminating in the south-central section of the county upon contact with sedimentary rocks of Triassic age. The remainder of the county is underlain by rocks of the Volcanic Slate Series and Triassic sediments. (See Plate II.) Boulder or flat-surface bodies of light gray, even-granular, massive granite were observed in a few localities in Granville County, being especially prominent in the vicinity of Oxford, the county seat, and along U. S. Highway 158 east of Oxford. So far as could be determined, none of the granite deposits in these areas has been utilized commercially and in only one locality, near Wilton in the southeastern section of the county, is granite presently utilized by the State Highway and Public Works Commission.

State Quarry: A small bench-type quarry, operated by the State Highway and Public Works Commission for the production of crushed stone for local road improvement work, is located 1.75 miles east of Wilton, in the extreme southeastern part of Granville County. The granite deposit in which the quarry is developed crops out as boulders and flat-surface masses over an area of approximately one-fourth square mile. The granite is a massive, deep pink, even-granular rock of medium texture. The prominent mineral constituents are quartz, pink feldspar, and uniformly distributed biotite. The exposed granite is cut into irregular blocks of varying dimensions by rather closely spaced joints, having strikes of N. 34° E. and N. 3° W., and further by horizontal sheeting planes at intervals of 1 to 4 feet. At many places in the quarry, vein quartz fills open joints; while in other places the joints are either unfilled or their open surfaces are coated with an iron sulphide mineral. At the time of the field work, the quarry was roughly circular and covered an area having a diameter of approximately 250 feet. A thin section prepared from a specimen of the granite from this quarry showed the following mineral composition:

Quartz	29%
Orthoclase	38%
Plagioclase (oligoclase)	29%
Biotite	3%
Others (muscovite, chlorite, apatite, and magnetite)	2%

According to this analysis, the rock falls into the class herein defined as quartz-monzonite. The most prominent microscopic characteristics of the rock are the closely interlocked feldspar and quartz grains, myrmekite, intergrowths of quartz and orthoclase, and the pronounced alteration of the feldspar constituents.

NORTHAMPTON COUNTY

The greater part of Northampton County lies in the Coastal Plain Province, granitic rocks cropping out only in the extreme northwestern part, in the vicinity of Camps Store and Henrico. (See Plate II.)

THE HENRICO AREA

A small, flat-surface mass of granite-gneiss crops out one mile west of the village of Henrico, in the northwestern part of Northampton County, about 11.5 miles WNW. of Camps Store. This small exposure of gneissic granite covers about 2 acres and is entirely free from vertical joints. The rock is a dark pinkish-gray, medium-grained, distinctly gneissic granite, showing complex intrusion by quartz, binary granite, and normal granite of a medium-grained, massive character. The granitic intrusives are lighter gray than the older gneiss and combine with the gneiss to form variegated migmatitic patterns through the entire deposit. The injection of the later materials has taken place along a consistent north strike. In many of the granite penetration zones, fragments of the older rock occur as essentially unaltered inclusions, and the segregation of biotite is common in the same areas. A distinct and regular sheeting of a convex-concave pat-

tern divides the rock into sheets approximately 4 feet in thickness. A thin-section analysis of the gneissic granite shows the following mineral composition:

Quartz	38%
Orthoclase	53%
Biotite-hornblende	7%
Others (microcline, chlorite, magnetite, apatite, zircon, and plagioclase)	2%

The rock has the mineral composition of biotite granite.

ORANGE COUNTY

Orange County lies almost entirely within the main belt of the Volcanic-Slate Series; however, granitic rocks are exposed in the southwestern portion of the county and schists and gneisses, in the extreme northwestern sections of the county. (See Plate II.)

The granitic rocks of Orange County are interesting because of the great variation in character between the granite of the southern part of the county and the granite exposed in the east-central portion of the county, near Hillsboro. In general, the granite exposures along the county line to the south of Chapel Hill are light grayish pink to deep pink and are more often even-granular, medium-textured granite of uniform composition. Feldspar is the predominant mineral in this granite, with quartz and other minerals usually constituting less than 25 percent of the total volume. In the vicinity of Chapel Hill, the granite assumes a rather uniform light gray color, in general contains a wider variation of mineral constituents, and contains in many places a considerable amount of epidote and inclusions of older rock. To the north of Chapel Hill, in the vicinity of Hillsboro, the granite contains numerous irregular inclusions of older basic volcanic rocks, which, in places, seem to have altered extensively the original granitic material by enrichment of the magma during assimilation. The Bacon Quarry, presently operated by the State Highway and Public Works Commission, is the only stone operation in Orange County utilizing granitic rocks.

THE BACON QUARRY

The Bacon Quarry of the State Highway and Public Works Commission is located in east-central Orange County, 4.3 miles northeast of Hillsboro and is engaged in the production of crushed stone for local road and highway improvement. The deposit in which the small bench quarry is developed forms a roughly circular hill, standing about 100 feet above the surrounding terrain. The rock is medium to dark gray, containing gray to pinkish-gray feldspars and quartz and numerous inclusions of the older volcanic rocks into which it was intruded. The texture is not uniform, and the mineral composition apparently varies from place to place within the quarry. The rock is distinctly a massive hybrid material, formed during the intrusion in volcanic slates of a magma which possessed poor assimilatory capacity. Inclusions in the rock range from less than one-half inch to more than 2 feet across and show various stages of reaction peripheral to their borders. Considerable epidote is disseminated through the rock, and veins and smears, or coatings, of epidote appear on the open-joint surfaces. Veins of calcite, up to 6 inches across, occur as joint filling in the highly sheared deposit. A thin section cut from a hand specimen of the rock shows the following mineral composition:

Quartz	13%
Orthoclase	13%
Plagioclase	62%
Epidote	10%
Others (sericite, magnetite)	2%

According to this analysis, the rock should be placed in the category quartz-diorite(?). Of interest in the examination of the thin section were the innumerable fine inclusions of epidote, giving the rock an extremely "dusty" appearance under the low-power lens. A considerable number of idiomorphic feldspars and the scarcity of interlocking mineral grains are also prominent microscopic features of the rock.

OTHER COUNTIES

Halifax, Johnston, and Chatham Counties constitute a part of the Northeast Piedmont and are partially underlain by granite rocks similar to those in adjacent counties. Because of a thick residual cover and consequent scarcity of outcrops, little time was spent in these counties during the investigation.

A porphyritic granite, probably a granodiorite, was seen along N. C. Highway 48 near Brinkleyville in the western part of Halifax County, during the investigation and was found to be highly weathered and friable. The granite contains large laths of plagioclase up to 1.5 inches across and often biotite and quartz grains of a uniform size of about one-half inch. Most of the feldspar grains show moderate to strong kaolinization. The rock is exposed for about 1.5 miles along the highway.

In Johnston County, granitic rock outcrops prominently in the vicinity of Clayton. Because of the time limitation during the investigation, the rock was not examined closely.

A southern extension of the granite body in Orange County crops out in northern Chatham County, about 2 miles south of the county line along U. S. Highway 15-501. The granite, similar to the deep pink variety found in southern Orange County, is even-granular, medium textured, and of a uniform composition. Feldspar is the predominant mineral component, with quartz and dark silicates usually occurring in small quantities of not more than 20 to 25 percent. In the vicinity of Bynum, 3 miles northeast of Pittsboro, light gray, medium-textured granite penetrates volcanic rocks of the Volcanic-Slate Series.

GRANITES OF THE CENTRAL PIEDMONT

The Central Piedmont is underlain largely by the most extensive bodies of igneous rocks in North Carolina, the Main Igneous Belt, or Carolina Igneous Belt of Watson and Laney, and the main body of slaty volcanic rocks, forming a large part of the Volcanic-Slate Series in the State. The eastern boundary of the Central Piedmont is formed by sedimentary rocks of Triassic age, and the eastern boundary of Person County, while the western limit is formed by the extensive pre-Cambrian gneiss-schist complex and the western line of Rockingham County. Virginia and South Carolina limit the region on the north and south, respectively. (See Plate III.)

The Main Igneous Belt is formed by a continuous body of granitoid rocks lying along a northeast-southwest axis from the South Carolina line to western Person County, attaining the greatest width, 35 miles, in the central and southern parts of the belt and the least width, 10 miles, at its northern terminus in Person County. It is within this belt that the widest variety of granitoid rocks in the State occurs. Of the various types present, perhaps granite and quartz-monzonite are the most aboundant; however, large areas within the divisions contain granodiorite, diorite, gabbro, and augite-syenite, all of which have been utilized more or less in the production of commercial stone. Also within this belt of rocks are large areas of older gneisses and schists, which interrupt locally the continuity of the granitoid rock bodies. Throughout most of the Central Piedmont, thick, buff to reddish-brown granite residuum covers fresh rocks; however, outcrops are more frequent and much larger than in the Northeast Piedmont, where boulder outcrops are common in many areas.

The geological associations between acid and basic rocks in the Central Piedmont become very complex in some localities, especially in areas adjacent to the Volcanic-Slate Series, but the complexities are not limited to this zone. Even in the central areas of the Main Igneous Belt, granite-diorite complexities are frequent and of such a nature as to pose very complicated associations. In many places, the relationship of granites and basic rocks strongly suggests multiple intrusion with granite penetrating older diorite-gabbro, while in other localities the relationship suggests diorite-gabbro invasion of granite. Dike materials of varied composition are prevalent throughout the region and are mentioned briefly in the appropriate section. The presence of gneissic structure in some of the granitic rocks of the Central Piedmont is sufficiently pronounced to suggest some dynamic metamorphism prior to or after consolidation of the emplaced magma. In others, the parallelism is almost certainly the result of incomplete assimilation, or a partial replacement by granite of the older gneissic and schistose rocks.

That portion of the Central Piedmont underlain by granites and related rocks includes parts of 15 counties, which, in order of granite and granite-gneiss production and commercial granite potential, are Rowan,

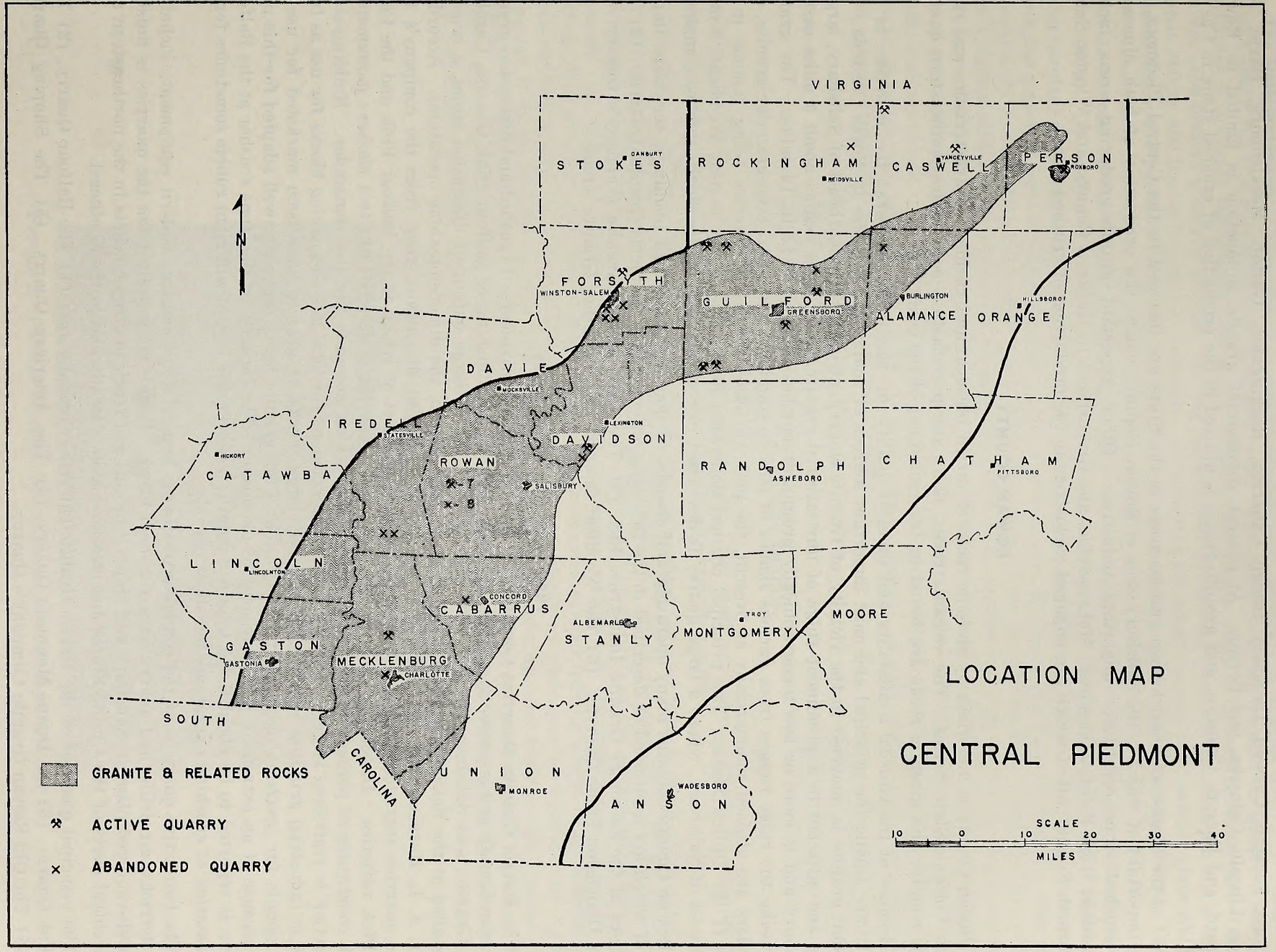
VIRGINIA
STOKES
GANBURY
ROCKINGHAM
REIDSVILLE
CASWELL
YANCEYVILLE
PERSON
ROXBORO
N
FORSYTH
WINSTON-SALEM
GUILFORD
GREENSBORO
BURLINGTON
ALAMANCE
HILLSBORO
ORANGE
DAVIE
MOCKSVILLE
IREDELL
STATESVILLE
LEXINGTON
DAVIDSON
HICKORY
CATAWBA
ROWAN
SALISBURY
RANDOLPH
ASHEBORO
CHATHAM
PITTSBORO
LINCOLN
LINCOLNTON
CONCORD
CABARRUS
ALBEMARLE
STANLY
TROY
MONTGOMERY
MOORE
GASTON
GASTONIA
MECKLENBURG
CHARLOTTE
SOUTH
CAROLINA
UNION
MONROE
WADESBORO
ANSON
GRANITE & RELATED ROCKS
ACTIVE QUARRY
ABANDONED QUARRY
LOCATION MAP
CENTRAL PIEDMONT
SCALE
10 0 10 20 30 40
MILES

PLATE III

Guilford, Forsyth, Caswell, Davidson, Iredell, Cabarrus, Rockingham, Gaston, Mecklenburg, Davie, Alamance, Lincoln, Catawba, and Person. At present, commercial granite production is limited to Rowan, Guilford, and Forsyth Counties, and granite-gneiss is utilized in the production of crushed stone in Caswell County.

Most of the largest and best known granite areas in the State are included in the Central Piedmont, the most important of which is the Salisbury area of Rowan County, where the production of both dimension and crushed stone constitutes important industries. Other important granite-producing areas include Stokesdale, High Point, Jamestown, McLeansville, and Greensboro, in Guilford County, and Winston-Salem, in Forsyth County, all of which are engaged exclusively in the production of crushed stone.

ROWAN COUNTY

Rowan County is underlain by plutonic rocks of varied physical and chemical characteristics and rocks of the Volcanic-Slate Series. The volcanic rocks, flows and pyroclastics, occupy the southeastern quarter of the county, and granitic rocks are found in the remainder of the county.

Because of the unusual availability and superior quality of the granitic rocks, the quarries in the county are among the principal and most important sources of commercial granite in North Carolina. Dimension granite is quarried in the vicinity of Granite Quarry, about 5 miles southeast of Salisbury, largely along and adjacent to a prominent ridge of unweathered granite. The ridge begins about 4 miles east of Salisbury and is more or less topographically prominent northeastward for 12 to 14 miles. The granite composing the ridge ranges from various shades of pink to standard light gray, even-granular granite, and all colors are utilized commercially at present, the pink varieties from the quarries being famous in all parts of the United States. The principal crushed-stone area in Rowan County is near Woodleaf, 9 miles northwest of Salisbury, where a large quarry is developed in rocks of the granite-diorite-gabbro complex.

Rowan County contains many operating and abandoned quarries and small openings, the more important of which are mentioned or described in the following order: (1) The Harris Granite Quarries, (2) The Quarries of the Salisbury Granite Industries, Inc., (3) The J. A. Logan Granite Company's Quarry, (4) Other Dimension Stone Quarries, (5) The Woodleaf Quarry, and (6) Other Granite Areas.

THE HARRIS GRANITE QUARRIES

The Harris Granite Quarries Company is among the oldest producers of crushed and dimension granite in Rowan County and is presently engaged in the quarrying and finishing of Balfour Pink Granite, Carolina Pink Granite, and Salisbury Gray Granite. In addition to the large output of dimension stone, a crusher is installed at the Balfour Quarry for utilizing the rubble from the dimension-stone operations. According to Mr. A. L. Harris, mining engineer, the annual production of dimension stone from the company's two active quarries averages approximately 20,000 cubic feet, most of which is the Balfour Pink and the Carolina Pink varieties. Dimension-stone production at the quarries is divided into two classes: monumental, which constitutes 80 percent of the total; and building, which accounts for the remainder. Building-stone production is restricted largely to blocks of small dimensions for local use and paving blocks for use as tube liners in industrial grinding equipment. Recently large blocks of granite have been marketed for use as base mounts for precision instruments, the Balfour Pink granite being especially well adapted for this purpose because of an extremely low coefficient of expansion. The capacity of the stone crusher at the Balfour Quarry is reported to be about 6,000 tons per month; however, the lack of sufficient rubble sometimes forces the cessation of crushing operations for short periods.

The two active quarries of the company producing rough stone employ modern equipment, including steel derricks, air drills, and quarry bars (channel bars). Rough-cut granite from the quarries is finished in a well-equipped plant in Salisbury and shipped by rail and truck to large markets in the northeastern and west-central parts of the United States and smaller markets locally and in the Southeast.

The principal quarries of the Harris Granite Quarries Company are: (1) The Balfour Quarry, (2) The Carolina Quarry, (3) the Dunns Mountain Quarry, (4) The American Quarry, (5) The Shuping Quarry, and (6) The Old Rowan Granite Company's Quarry.

The Balfour Quarry: This quarry is located one-half mile southeast of Granite Quarry, in south-central Rowan County, 0.3 of a mile west of U. S. Highway 52. The deposit in which the Balfour Quarry is developed constitutes a moderate topographic rise and is a part of the granite ridge of the southeastern part of Rowan County. The present quarry, a pit-type opening, ranges from 100 to more than 150 feet in depth and is approximately 300 by 800 feet in horizontal dimension. Over most of the quarry area, 1 to 12 feet of yellowish-brown residual decay and partially decayed granite have been removed during the quarrying operations. The deposit is essentially massive, being cut by widely spaced joints which strike N. 10° E. and N. 70° W. Of considerable interest during the inspection of the quarry was the relationship of the principal plane of jointing, N. 70° W. and the color of the granite. At the north end of the quarry, the deposit consists of medium gray, even-granular, medium-grained granite, which continues toward the south end of the quarry to a point at which the principal joint surface cuts the deposit. At this point, in a space of only 2 to 3 feet, the color passes transitionally to a bright pink granite. The pink color continues for about 30 to 40 feet and changes to a distinctly lighter pink granite immediately beyond a joint surface, parallel to the first. Toward the south end of the quarry, the light pink granite grades slowly into a bluish-gray granite and further on, to a blue-gray-pink hybrid rock. Natural sheeting planes, if present in the granite, are not distinguishable from the many artificially induced planes. The greatest production from the quarry consists of a bright pink, slightly gneissic granite, in which dark silicate minerals are almost entirely absent. A thin section cut from the Balfour Pink granite shows the following mineral composition:

Quartz	32%
Orthoclase	35%
Plagioclase	33%
Others (muscovite-sericite, apatite, titanite, magnetite, and chlorite)	2%

According to this analysis, the rock is a quartz-monzonite. The most prominent microscopic feature of the rock is the pronounced interlocking character of feldspar and quartz grains.

The Balfour Quarry has been in almost continuous production for more than 40 years, and it is estimated that 20,000,000 cubic feet or more of granite have been removed during its operation. Much of this production has been shipped to all parts of the United States and other parts of the world, and during the past 40 years pink granite from the Balfour Quarry has become a standard on the granite market of the United States. The principal products from the quarry are monumental stock, paving blocks, large building blocks, small building blocks, and curbing. Figure 2 shows paving blocks of pink granite stacked and ready for shipment from the Balfour Quarry. The stone is quarried by using plugs and feathers and channel bars to separate the blocks from the quarry wall and is removed from the quarry by electrically operated hoists. Subdivision of the large blocks is accomplished by plug and feather wedging. The granite is reported to work well, and it takes a brilliant abrasive polish.

FIGURE 2. PAVING BLOCKS, BALFOUR QUARRY, ROWAN COUNTY

The Carolina Quarry: The Carolina Quarry is located 4 miles southeast of Salisbury, immediately northeast of Dunns Mountain. The granite is a medium pink, even-granular, medium-grained stone, comparable in physical characteristics and color to the Balfour Pink; and, like the Balfour stone, it works well and takes an excellent abrasive polish. The granite is essentially the same rock as that quarried at the nearby Salisbury Granite Industries, a thin-section analysis of which can be found on page 31. It is a shallow, pit-type quarry, roughly rectangular in plan and covering about 3 acres. Work at the quarry is intermittent, and water had partially filled the opening at the time of the investigation. Prominent but widely spaced joints cut the deposit at N. 45° E. and N. 25° W., but sheeting planes appear entirely absent below a 1- to 2-foot surface sheet of partially decayed granite. Residual overburden attains thicknesses up to 5 feet in the vicinity of the quarry. The granite from the Carolina Quarry is used principally for monuments.

The Dunns Mountain Quarries: Dunns Mountain, the most prominent topographic feature in the Rowan County granite area, was the scene of considerable quarrying activity in past years; however, the extreme toughness and the poor workability of the stone, due to the lack of well-developed rift and grain, have resulted in the complete closing of the quarries. The "mountain" is located 4 miles southeast of Salisbury and 1.5 miles east of U. S. Highway 52, in the east-central part of Rowan County. Several quarries operated on the slopes of Dunns Mountain produced both gray and pink varieties of granite for many years, production being restricted largely to blocks of varying dimensions and curbstone. Both the pink and gray granite of the Dunns Mountain deposit are even-granular and alike in mineral composition, differing only in the color of the orthoclase feldspar constituent. Joints, having strikes of about N. 70° E. and N. 55° E., traverse the deposit at wide intervals, and in some places the joint surfaces are coated with a thin veneer of epidote showing slickenside striations. Residual overburden is very thin or absent, and steep slopes developed in granite can be seen at almost any place on the mountain. A thin-section description of the pink granite by Watson and Laney shows the following mineral constituents:

> ". . . an aggregate of feldspar and quartz with no dark bisilicate. . . . Finely striated acid plagioclase may equal or exceed . . . the potash feldspar. Microcline is present only in subordinate amounts. . . . scattered grains of magnetite . . . are noted through the section."

On the basis of this description, the granite falls into the class quartz-monzonite, though the apparently excessive amount of plagioclase in some phases of the rock may place it in the class granodiorite.

The American Quarry: Beginning immediately southwest of Dunns Mountain and continuing to within one-half mile of Granite Quarry, a series of small openings and prospects have been made in gray, medium-textured granite on a tract of land formerly known as the McCanless property. This series of small openings is terminated at the southwest end by the American Quarry, a large, water-filled, abandoned opening. The quarry is approximately 200 by 500 feet in areal dimension and more than 100 feet deep. The granite is a light gray, medium-textured rock and is reported to work well and take a brilliant abrasive polish. Joints, having strikes of N. 35° W. and N. 15° E., cut the granite at moderately wide intervals, and most of the joint planes are slickensided. Overburden in the quarry area ranges from 5 to 10 feet and is underlain by 1 to 10 feet of sap granite. During operation, both dimension and crushed stone were produced in large quantities, dimension stone having been shipped to points as distant as Reading, Pennsylvania, and Washington, D. C., as early as 1903.

The Shuping Quarry: The Shuping Quarry is located in the town of Faith, 5 miles south of Salisbury and 2 miles west of U. S. Highway 52. Owned by the Harris Granite Quarries Company, the Shuping Quarry is leased to J. T. Ritchie for the production of dimension granite.

The quarry is developed in a low dome-like mass of light gray to very slightly pinkish-gray, medium-grained granite, which crops out over approximately 3 acres. The granite is essentially fresh from the surface downward. Vertical joints, at widely spaced intervals, cut the deposit in the following directions: N. 10° E., N. 10° W., N. 45° E., and N. 50° W., and sheeting planes divide the granite into layers, ranging in thickness from 6 inches at the surface to about 10 feet in the lower parts of the shallow, bench-type quarry. The granite is an aggregate of closely interlocked grains of quartz and feldspar, about 10 percent of uniformly distributed biotite, and a small amount of epidote. Well developed rift and grain in the deposit respond excellently to quarrying and subdivision by plug and feather wedging. The principal products from the quarry are building blocks of small dimensions for local use and curbing and sills for shipment out of the State.

The Jones Quarry, located two-tenths of a mile southeast of the Shuping Quarry, is also operated by Mr. Ritchie for the production of small building blocks, the granite being similar to that from the Shuping Quarry but of a lighter color because of less biotite.

The Old Rowan Granite Company's Quarries: Within the corporate limits of Granite Quarry, considerable quarrying activity was carried on at several openings from about 1900 to as late as 1930. Two large quarries are located about 100 yards northeast of the railroad depot, and smaller openings are found at close intervals to the southwest and toward the Balfour Quarry, to the southeast. Granite from these quarries is similar in composition and texture. A hand specimen of the light gray granite shows closely interlocked grains of quartz and feldspar, no biotite, and a considerable amount of the accessory mineral, magnetite. Even in a hand specimen, kaolinization of the feldspar constituent is apparent.

The deposit forms a large dome-like mass, covering about 4 acres, and the larger of the two bench-type quarries developed in the deposit covers about an acre. The depth could not be determined because of water in the quarry, but it is reported to be in excess of 30 feet. Joints, striking N. 40° E. and N. 40° W., cut the deposit into blocks of varying dimensions. Residual decay and sap granite covering the granite range from 5 to 15 feet in thickness.

QUARRIES OF THE SALISBURY GRANITE INDUSTRIES, INC.

Since its entrance into the Salisbury granite area in 1932, the Salisbury Granite Industries, Inc., has become one of the most efficient and modern granite quarrying operations in the Nation. The granite area presently controlled by this company lies approximately 1 mile northeast of Dunns Mountain and 4 miles southeast of Salisbury. The deposit is characterized by extensive flat-surface and boulder outcrops of medium-grained, even-granular, pink granite of extreme hardness but excellent workability. A total of eight openings has been made over the area, but present quarry operations are confined largely to a single opening developed in massive, pink granite in the southeastern part of the property. Production from the quarry is limited to dimension stone of varying sizes for finishing into monumental stock of the finest quality. The principal opening, a pit-type quarry rectangular in shape, is about 150 feet in length and 120 feet in width and has been worked to an average depth of 35 feet in about 4 years of operation. Production from this quarry apparently has exceeded 500,000 cubic feet, the larger part of which has been available for finishing and marketing. Shipments from the plant are made by motor freight and railroad to markets throughout the United States. Recently, a shipment was made to Hawaii. The stone is marketed under the trade name "Salisbury Pink Granite," and the annual production averages 50,000 to 75,000 cubic feet.

The deposit in which the principal quarry has been developed is cut by very widely spaced and largely closed joints, having strikes of N. 50° E. and N. 25° W. These joints in no way interfere with the production of dimension stone of any desired size. Plug and feather wedging and channel bar separation are employed ing the quarrying of the granite as well as in the subdivision of the large blocks. Electrically operated steel derricks and hoists are used to remove the blocks from the quarry. Because natural sheeting planes are absent in the deposit, it is necessary to rely on artificially induced sheets for the horizontal parting of the granite. Black powder is used for cleaving sheets of any desired thickness, and usually a single lift is made over an area of 1,000 to 2,000 square feet and worked until exhausted. Because of efficiency of operation, waste from the quarrying procedure is held to a minimum. The granite is cut and finished in a modern, well-equipped plant into various types and sizes of monuments and to a lesser extent finished building blocks. The plant is equipped with gang saws, contour machines, high-speed polishing mills, and diamond saws. According to Mr. C. R. Deadwyler, manager of the quarries and finishing plant, wire saws will soon be installed to add facility to the plant's operation.

The granite is a bright pink rock, showing an even distribution of the quartz and feldspar constituents and minor amounts of bright green epidote and bluish magnetite. A thin section cut from a hand specimen of the granite shows these minerals in the following percentages:

Quartz	33%
Orthoclase	47%
Plagioclase	19%
Others (biotite, epidote, magnetite, and muscovite)	1%

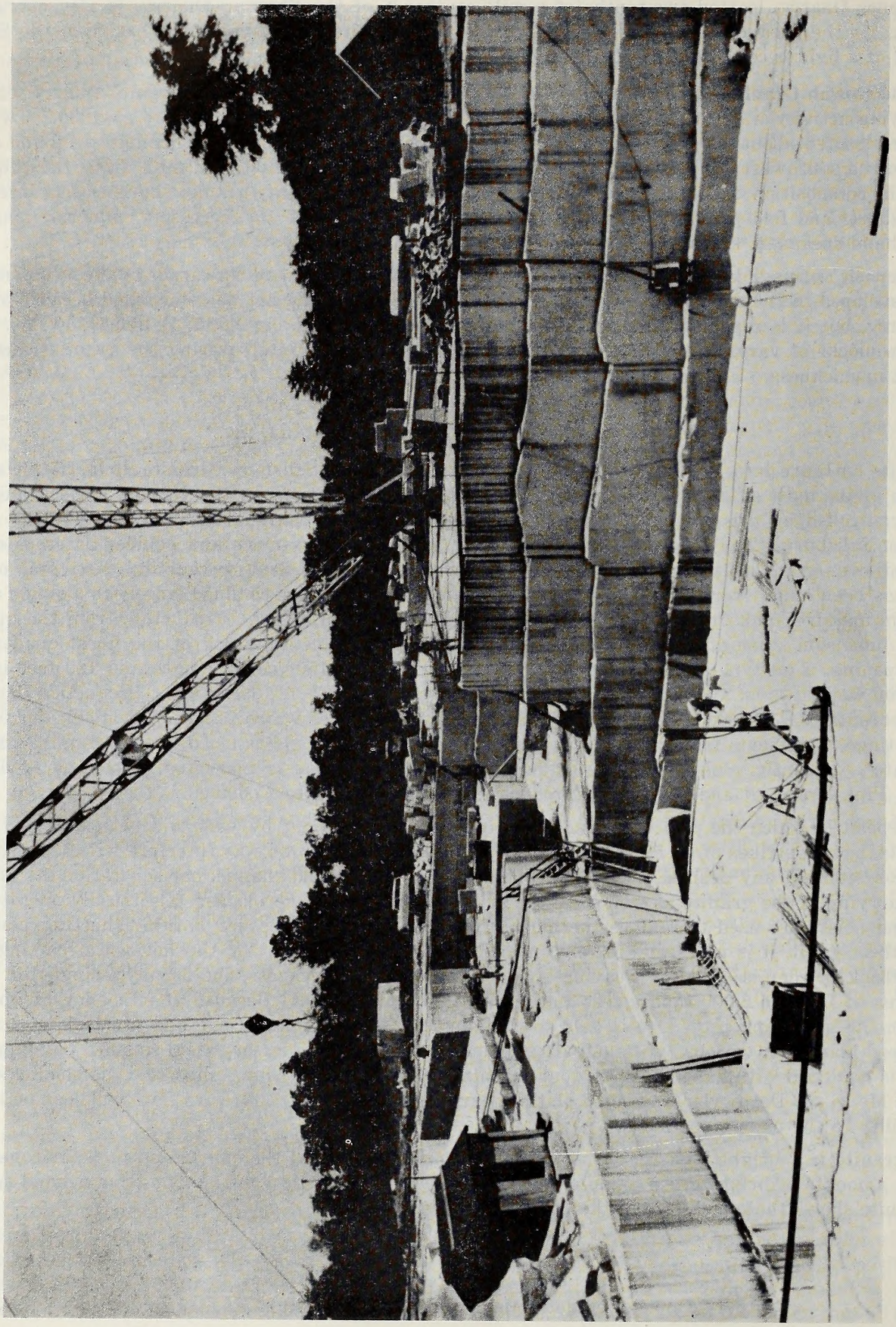

FIGURE 3. PRINCIPAL QUARRY OF SALISBURY GRANITE INDUSTRIES, INC., ROWAN COUNTY.

According to this analysis, the rock is placed into the class granite; however, the normal amount of bisilicate minerals in granite is not present in this stone. The most pronounced microscopic characteristic of the rock is the closely interlocked grains of quartz and feldspar and the shattered appearance of the grains.

During the course of the investigation, quarrying operations were observed both in the crushed-stone and dimension-stone industries, but none has been more efficiently developed than the principal quarry of this company.

THE J. A. LOGAN GRANITE COMPANY'S QUARRY

The J. A. Logan Quarry is located in the southern corporate limits of the town of Faith, 5.5 miles southwest of Salisbury. The area in which this small pit-type quarry has been developed is characterized by low, flat-surface outcrops of granite and a few widely scattered granite boulders. The quarry is roughly circular, with a diameter of about 150 feet and an average depth of approximately 20 feet. The deposit is essentially massive, containing neither well defined planes of jointing nor sheeting planes of any consequence, rendering it necessary to use the plug and feather wedge method and the channel bar for the separation of blocks from the quarry wall. Lift sheets are produced over areas up to 2,000 square feet, using the black powder method; however, due to the horizontal attitude of the rift, a lifted sheet can be subdivided horizontally to any desired thickness by the use of plugs and feathers. The operation is modern in every way, the equipment consisting of electrically operated steel derricks and hoists, air drills, and channel bars. The principal products from the quarry are monumental stone, building stone of large dimensions, and small building stones for local use. According to Mr. J. A. Hosselton, quarry superintendent, annual production exceeds 35,000 cubic feet, most of which is shipped by rail to cutting and finishing plants in Northeastern United States and also to the cutting and finishing plant at Mt. Airy, Surry County.

The granite, a medium-grained, even-granular rock, ranges in color from a faint pinkish-white, marketed under the trade name Arabian Pink, to a light pink variety, marketed as Coral Pink. The pinkish color of the Arabian Pink variety from the quarry is due to minor oxidation(?) of the iron oxide mineral magnetite, while the Coral Pink stone owes the pink coloration to an even distribution of light pink feldspars in the rock. The mineral constituents are distributed uniformly through the granite and possess a strong interlocking character. A thin section cut from a specimen of the Arabian Pink stone shows the following mineral percentages:

Quartz	25%
Orthoclase	32%
Plagioclase	42%
Others (magnetite, epidote, titanite, biotite)	1%

According to this analysis, the Arabian Pink granite is a quartz-monzonite.

OTHER DIMENSION STONE QUARRIES

Many abandoned or sporadically operated granite quarries and small openings are found in many areas in and around the towns of Faith, Granite Quarry, Rockwell, and Barbers Junction, in Rowan County. In the area around Granite Quarry, more than 25 such openings were observed within a two-mile radius, and a similar number of small openings probably exists in the area around Faith.

Two quarries not previously discussed merit at least a short description because of the products from one and the rock type formerly utilized at the other:

The Barnhardt Quarry: This quarry is located in the town of Faith, a few hundred feet southwest of the J. A. Logan Company's quarry, and is developed in a rock type similar to the Arabian Pink of the Logan Quarry, though the minor iron oxide stains are absent, rendering the stone a pleasant light gray to white. At places in the quarry, the granite grades to a light pink. It is a pit-type opening and is partially filled with water. According to Mr. McCombs of Faith, the granite works very well into curbing and paving blocks. The principal products from this intermittently operated quarry are curbing, tube mill liners, and grinding pebbles, the mill liners and pebbles being for use in industrial grinding machines in which the finished product must be extremely low in iron content.

The Bear Poplar Gabbro Quarry: The Bear Poplar Gabbro Quarry (McGalliard Quarry) is the name given the abandoned quarry of the old Consolidated Granite Company near Bear Poplar, 12.5 miles west of Salisbury and 5.5 miles southwest of Barbers Junction. The quarry is developed in large boulders and flat-surface outcrops of black, medium-grained, even-granular gabbro (norite) and is reported to have been worked for dimension stone as early as 1899. In 1903, Watson and Laney reported the stone was marketed as black granite in Ohio, New York, Indiana, and several southeastern states and was becoming a popular monumental stone in some parts of North Carolina. The deposit appears to be a large differentiated body of gabbro, though it is somewhat similar in composition and texture to the ophitic textured, or biabasic, dikes found throughout the Piedmont Plateau in North Carolina. A thin-section description of this stone by Watson and Laney follows:

> ". . . containing much biotite, . . . orthorhombic and monoclinic pyroxenes largely hypersthene, plagioclase, a little orthoclase, some hornblende, a sprinking of quartz, and titaniferous magnetite."

THE WOODLEAF QUARRY

The Woodleaf Quarry is located in the village of Woodleaf, 10 miles northwest of Salisbury, in an area characteristic of the granite-diorite-gabbro complex. The large pit-type quarry is developed in plutonic rocks of two genetic types, gabbro and granite, both of which show apparent intrusion into the other from place to place in the quarry. Contacts in the granite-gabbro areas exposed in the quarry face are rather sharp, generally grading from one rock type to the other in a space of 1 to 2 feet. The medium gray granitic rock is an even-granular, medium-grained stone, containing abundant quartz, feldspar, and biotite showing strong parallelism. Epidote, magnetite, and pyrite are the principal accessory minerals. In the granite areas of the quarry, numerous well defined angular inclusions of a dark cryptocrystalline igneous rock are comomn and in some places constitute a textural characteristic of the intrusive granite. On the basis of megascopic examination and comparison with volcanic rock types found farther east in the Central Piedmont, it is believed that the inclusions represent remnants of extensive andesitic flow rocks of the Volcanic-Slate Series into which the acid plutonic rocks have been intruded. A petrographic analysis of a granitic rock from the general area of the quarry is reported by Watson and Laney, as follows:

> ". . . biotite granite in which the principal minerals, feldspar and quartz, interlock in a very irregular and intricate fashion. . . . Plagioclase as single individuals entirely fails. . . . The feldspar is considerably altered principally to muscovite. . . . some epidote is noted."

According to this description, the rock falls into the class biotite granite.

The gabbroic rock is a dark gray, medium-grained rock showing in some places a porphyritic tendency. Dark silicate minerals and plagioclase are the most abundant mineral constituents. A thin section cut from the rock shows the following mineral percentages:

Plagioclase	33%
Orthoclase	10%
Biotite	12%
Pyroxene (mostly hypersthene)	44%
Others (titanite, sericite)	1%

According to this analysis, the rock is placed in the class gabbro (norite). Of considerable interest in the examination of the thin section were the closely interlocked grains, the development of micropoikilitic structure, and the distinctly gneissic structure of the rock.

Structurally, the rock deposit utilized in this production of crushed stone at Woodleaf is moderately sheared by vertical joints, striking N. 20° E. and N. 60° E., and further broken by well developed sheeting planes at intervals of 2 to 15 feet. It was also observed that one of the principal directions of vertical jointing is almost always present along the acid rock-basic rock contact in the quarry; however, the sheeting planes are continuous across the contact zones. Throughout the quarry, quartz veins containing a considerable amount of pyrite intersect the older rocks; and veins of calcite, distinctly younger than the quartz, are common in highly jointed areas as joint filling. Epidote, probably associated with the formation of the calcite, occurs as a coating on open-joint surfaces and as fine stringers in the rock.

The quarry is equipped with the most modern tools of quarrying, crushing, and hauling, including well drills, quarrymaster drills, heavy-duty Diesel trucks, belt conveyors, and primary and secondary crushers. The plan of quarrying over the years has resulted in the development of a pit-type quarry, covering about 10 acres, in which a 100-foot level is the principal production level and a 150-foot level is the drainage and waste level. According to Mr. H. C. Burgess of the Superior Stone Company, the Woodleaf Quarry has been operated almost continuously since 1921. The principal product of the operation is crushed stone for use as concrete aggregate.

OTHER GRANITE AREAS

Granite areas of some significance in the production of stone in Rowan County in past years are located, as follows:

Phillips Mountain: This is a low, large-diameter topographic rise, located about one mile southwest of Faith. As early as 1903, small quarries were operated in the area for the production of curbing from a light gray, medium-textured granite. No production is made in the area at present.

Powlers Mountain: Powlers Mountain is the name given to a low dome-like mass, located 3 miles southwest of Faith and 9 miles southwest of Salisbury. Many years ago, some quarrying was carried on in the area, apparently for stone for local use. The granite is a light gray, medium-grained rock in which biotite or other dark silicates are almost entirely absent.

Area of Porphyritic Granite: An area of porphyritic granite is exposed in places, beginning about 2 miles northwest of Salisbury and extending for about 5 to 6 miles northwestward. The granite is a medium to dark gray and contains idiomorphic grains of orthoclase feldspar up to 2 inches across and large amounts of medium-grained biotite. According to Watson and Laney, a small production of crushed stone was made from the granite at a point 3 miles northwest of Salisbury on the Old Wilkesboro Highway.

BASIC ROCKS

Basic rock types have wide distribution over Rowan County, occurring as diabase and schistose dikes and medium-grained basic differentiate masses. The principal areas of occurrence of the medium-grained basic rocks are located in the vicinity of Barbers Junction, 10 miles northwest of Salisbury and extending southwest toward Bear Poplar, 17 miles west of Salisbury, and around Woodleaf in northwestern Rowan County. Basic dikes are found throughout the granitic rock areas of the county, being especially prevalent in areas of the granite-diorite-gabbro complex.

GUILFORD COUNTY

Except for limited areas of volcanic rocks in the south and schists and gneisses along the northern boundary, Guilford County is underlain by granitic rocks of varied texture and mineral composition, some of which are utilized in the production of crushed stone. (See Plate III.) The present commercial granite-producing areas of Guilford County are located near McLeansville, Stokesdale, Jamestown, High Point, and Greensboro. Noncommercial stone is produced by the State Highway and Public Works Commission at the Pearman Quarry in northwest Guilford County.

THE MCLEANSVILLE QUARRY

The McLeansville Quarry is located in east-central Guilford County, one mile west of the community of McLeansville and 5 miles east of the corporate limits of Greensboro. The quarry was acquired by the Superior Stone Company in 1948, from which time large amounts of crushed stone for use as road metal and concrete aggregate have been produced and marketed in central North Carolina. According to Mr. P. M. Williams of the company, the maximum daily production during this period has ranged from 3,000 to 3,500 tons. The quarry utilizes the most modern equipment, including percussion drilling machines for the drilling of shot holes, jackhammers, heavy-duty Diesel trucks, primary and secondary crushers, and belt conveyers.

The pit-type quarry is developed in a flat-surface mass of rocks, covered in some places by 20 to 30 feet of buff to reddish-brown residuum, derived from the underlying light and dark colored, medium-grained

granitic rocks, basic volcanic rocks, and schistose and diabasic lamprophyre dikes. The basic volcanic rocks, probably of andesitic composition, occur as large, well defined inclusions in the darker colored granitic rocks and are believed to represent remnants of a volcanic flow rock belonging to the Volcanic-Slate Series, into which granite magma was emplaced. The darker phase of the granitic rock in the quarry appears to have been intruded by a light gray granitic rock, containing no inclusions but intricately intermingled with the older material, the intricate association probably resulting from an intrusion of the acid magma into the incompletely consolidated darker magma. Over most of the deposit, stringers of epidote and quartz and cubes of pyrite, up to one inch across, are contained in both the light and dark rocks and in the schistose intrusives. The diabasic lamprophyre dikes do not contain epidote, quartz, or pyrite. The rocks are rather moderately sheared throughout their exposure in the large shallow quarry. A thin section cut from a specimen of the lighter colored granitic rock shows the following mineral composition:

Quartz	20%
Orthoclase	16%
Plagioclase	58%
Biotite	3%
Others (chlorite, apatite, magnetite, epidote, titanite)	3%

According to this analysis, the rock falls into the class granodiorite.

THE GUIL QUARRY

The Guil Quarry is located 2.5 miles east of Stokesdale, 11.5 miles northwest of the corporate limits of Greensboro, and adjacent to N. C. Highway 65. According to Mr. Eller, quarry superintendent, the Guil Quarry was first opened by Guilford County for the production of crushed material for the improvement of county roads and was operated an unknown number of years for that purpose. Since 1948, the quarry has been operated by the Piedmont Quarries Company of Winston-Salem. Maximum daily production during this time is reported as 1,000 tons, the greater part of which is marketed as concrete aggregate and road metal in Guilford and surrounding counties. The quarry is developed in a low dome-shaped mass of granitic rock, in places covered by buff to reddish-brown residuum, which ranges in thickness from 2 to 25 feet. The quarry is approximately 1,200 feet in length, 300 feet wide, and 150 feet deep, making it an excellent example of a pit-type opening. The deposit is penetrated by binary granite dikes up to 5 inches in width, which show minor fault displacement at the north end of the quarry. Along the plane of faulting, the surfaces of the granite are coated with a mixture of calcite and epidote, and the feldspars of the granite are deep red in color for 1 to 2 inches away from the plane of faulting. Minor amounts of epidote are disseminated through the rock, and 1- to 2-inch isolated or segregated areas of quartz are common in certain zones of the rock. The rock is light to medium-gray granite of medium texture, containing a considerable amount of biotite, which sometimes segregates, and a large amount of quartz. The feldspar constituent is composed of microcline, orthoclase, and a little plagioclase. In mineral composition and general appearance the granite is very similar to that quarried at the State Highway and Public Works Commission's Pearman Quarry, located 4.5 miles to the southwest. A thin-section description of granite from this quarry can be found on page 37.

THE JAMESTOWN QUARRY

The Jamestown Quarry is located 2 miles south of Jamestown, 7.5 miles south of the corporate limits of Greensboro, and 0.5 of a mile north of Kivette Drive, east of High Point. According to Mr. Whitlow, operator, the quarry was first opened by the United States Civilian Conservation Corps and was operated until 1935, producing crushed stone for use as concrete aggregate and road metal. Since September of 1952, the quarry has been operated by Whitlow Brothers of High Point, and at present the operation produces a maximum of 700 tons of crushed stone daily, most of which is marketed locally.

The rock from the small bench quarry is a medium gray, even-granular granite of medium texture, containing uniformly distributed biotite and much quartz. It displays a moderate gneissic structure, showing a parallelism of the biotite constituent. The deposit, covered by residuum up to 20 feet thick, is intruded by small diabase dikes and is moderately sheared by joints, having strikes of N. 23° W. and N. The quarry operation is modern in every respect, being equipped with pneumatic tools, heavy-duty trucks, and a small, compact crushing plant.

THE HIGH POINT QUARRY

The High Point Quarry is located 1 mile south of Kivette Drive, 2.5 miles east of High Point, and along Two-Mile Creek. Operated by Whitlow Brothers of High Point since 1947, the quarry produces large amounts of crushed aggregate for the market area around the city of High Point. The bench-type quarry is developed in a shattered body of granite, similar to that utilized at the Jamestown Quarry, but the rock contains more biotite and displays a strongly gneissic structure. Small amounts of pyrite and epidote are disseminated through the rock. The buff colored residual overburden, ranging in thickness from 2 to 50 feet, contains many boulders of exfoliated granite.

THE BUCHANAN QUARRY

The Buchanan Quarry, owned and operated by Mr. G. C. Buchanan, is located 2.7 miles south of the corporate limits of Greensboro, 0.2 of a mile east of U. S. Highway 421, and adjacent to Little Alamance Creek. The quarry, a circular, pit-type opening having a diameter of approximately 300 feet, was opened in 1940 and has been operated continuously since that time in the production of crushed aggregate for the local market. Equipment in use at the quarry consists of a modern, compact crushing plant, wagon and well drills, heavy-duty Diesel trucks, power shovels, and pneumatic tools, all of the latest design. The quarry is developed in a gentle topographic swell, formed by rocks of the granite-diorite complex type which show moderate jointing and rather deep weathering. The depth of combined residuum and sap rock ranges from 10 to 25 feet in the quarry area. The principal rocks consist of fine- to coarse-grained diorite(?) and irregular shaped areas of younger medium-grained granitic rocks. Large blocks of an ivory colored, highly siliceous, fine-grained rock appear as inclusions in the diorite, and many dark lamprophyre and granite dikes, ranging from one inch to several feet across, penetrate the above rock units. Over most of the quarry area the medium- and coarse-grained rocks show moderate to strong gneissic structure and contain large amounts of biotite and hornblende.

THE PEARMAN QUARRY

The Pearman Quarry is located in northwest Guilford County, 2 miles southwest of Stokesdale and 0.7 of a mile south of U. S. Highway 158. The quarry was reportedly opened by the State about 1937 for the production of crushed stone for use as road metal in Guilford and adjacent counties. At present most of the small production is used for improvement of secondary roads in Guilford County. The opening is a perfect example of a well developed bench quarry, offering an almost level access road and natural drainage. Structurally, the deposit is cut into small, irregular-shaped blocks by a complex system of closely spaced, vertical joints and well developed sheeting planes at 2- to 5-foot intervals. The residual overburden ranges from 2 to 10 feet in thickness. The deposit is intersected by two prominent binary granite dikes, about one foot in width, which strike northeast.

The rock is medium-grained, even-granular granite, showing a strong parallelism of the abundant biotite and hornblende constituents and containing a large amount of quartz and a considerable amount of finely divided epidote. The biotite and hornblende are most prominent in the rock when occurring together as almost solid bands of the two minerals. These bands appear to be relict bedding planes in the highly feldspathic rock. A thin section cut from a specimen of the rock shows it to be a biotite-hornblende gneissic granite, having the following mineral composition:

Quartz	27%
Orthoclase	58%
Biotite and hornblende	12%
Others (magnetite, myrmekite, sericite, calcite, chlorite, muscovite, epidote)	3%

OTHER GRANITE AREAS

Igneous rocks or meta-sedimentary granite-gneisses have been utilized in many areas of Guilford County in the past, the more important localities being:

Browns Summit and Vicinity: Browns Summit is located 8.5 miles northeast of Greensboro and 1.5 miles west of U. S. Highway 29. The granite in this vicinity is a light gray, medium-grained gneissic granite, con-

taining abundant muscovite, biotite, quartz, and feldspar. This rock has been utilized in the production of crushed aggregate in past years. A thin section of granite from a deposit 1.5 miles southeast of the town is described by Watson and Laney, as follows:

> ". . . a biotite granite . . . composed of an aggregate of quartz, microcline and orthoclase with very scant plagioclase. . . ."

According to this description, the granite is classed as normal, or biotite, gneissic granite.

Summerfield and Vicinity: Summerfield is located on U. S. Highway 220, 12 miles northwest of Greensboro. Granite from many small openings in the vicinity, formerly utilized largely on a noncommercial basis, is a light to medium gray, even-granular, medium-grained stone which in some restricted localities has a porphyritic tendency. Most of the granite outcrops in this area show a marked gneissic structure. A petrographic description by Watson and Laney follows:

> ". . . biotite granite of closely interknit feldspars and quartz . . . biotite largely altered to chlorite . . . Single plagioclase individuals are absent."

The rock falls into the class biotite gneissic granite.

Greensboro Area: Several abandoned quarries are located within Greensboro and in the area immediately adjacent. Several of these openings were visited, but none were examined closely. In general, the quarries are developed in light- to medium-gray granite of an even-granular, medium-grained texture and of a variety similar to the medium-gray granite of the McLeansville Quarry. Work at the quarries visited was suspended many years ago.

BASIC ROCKS

Basic rocks, including diabase and schistose dikes and medium-grained differentiate masses, have widespread occurrence in Guilford County. A diabase dike, 100 feet in width and having a northeast strike, can be seen one mile west of Greensboro, along U. S. Highway 220 on Battleground Avenue. Other dikes of smaller dimension are especially prevalent in the northeast section of the county. Schistose dikes and diabase gabbro dikes can be seen along U. S. Highway 70 east and 420 southeast of Greensboro and in localities west of the city.

FORSYTH COUNTY

Granitic rocks containing a relatively large proportion of quartz underlie the southeastern third of Forsyth County but are presently utilized in only one locality, at the Piedmont Quarry in Winston-Salem. The remaining part of the county is underlain by gneisses and schists and a narrow belt of Triassic sediments along the north-central border of the county. (See Plate III.)

THE PIEDMONT QUARRY

The Piedmont Quarry is located a few hundred feet outside the eastern city limits of Winston-Salem and one-half mile north of N. C. Highway 150. The area in which the large bench-type quarry is developed is characterized by flat-surface masses of light gray, medium-grained, slightly gneissic granite, containing large included masses of biotite gneiss and small dikes and veins of hydrothermal quartz and binary granite. Throughout the general area, residual decay is rather thin, constituting an overburden of less than 12 feet in the immediate vicinity of the quarry.

The granite portions of the quarry and the large quartz-biotite gneiss inclusions are distinct units in the quarry walls, showing restricted gradational contacts but otherwise appearing to be separate intrusions. Only the presence in the granite of smaller well defined inclusions of a similar gneiss gives conclusive evidence of the included relationship of the large gneiss bodies. The slightly gneissic structure of the granite, showing a parallelism of the biotite constituent, seemingly represents relict bedding planes of those portions of the gneiss which were not completely assimilated by the granite. The presence of excessive amounts of silica in the parent granite magma is evidenced by large quartz segregations in both the granite and the gneiss. Structurally, the rock mass is moderately sheared, however only one prominent joint could be determined, it having a strike of N. 75° W. The quarry covers an area having a length of 600 feet and a width

of 300 feet, and the quarry floor ranges from 75 to 100 feet below the general ground surface. According to Mr. L. M. Seawell, president of Piedmont Quarries, this quarry was first opened in 1929 and has been in continuous operation since that time. The maximum production, which is reported as 750 tons daily, is restricted to crushed stone of various linear sizes for use as concrete aggregate. The market area for this product is Winston-Salem and the immediate environs.

A thin section, cut from a specimen of medium-grained granite from the quarry and analyzed petrographically by the U. S. Bureau of Public Roads, shows the following mineral composition:

Quartz	39%
Orthoclase	39%
Plagioclase	10%
Microcline	6%
Biotite	5%
Muscovite	1%

According to this analysis, the rock is a biotite granite. In some places in the quarry, the rocks contain grains and crystals of almandite(?) garnet as a prominent accessory mineral.

ABANDONED QUARRY (PIEDMONT)

This quarry is located two miles southeast of the corporate limits of Winston-Salem and adjacent to N. C. Highway 109, near the confluence of Fiddler and South Fork Creeks. The bench-type quarry, covering about one-quarter of an acre and worked to an average depth of about 20 feet, is developed in a low dome-like body of massive, light gray granite which varies in texture from medium to porphyritic, the outsized fraction in the porphyritic phase usually consisting of grains of orthoclase up to three-quarters of an inch across. Biotite and muscovite are distributed evenly through all texture phases of the rock, and occasional segregations of quartz are also present in the exposed rock at many places. The deposit is penetrated by one coarse pegmatite body, containing books of biotite up to three inches across, and throughout the deposit small, ill-defined inclusions of biotite gneiss showing partial alteration to granite are rather numerous. The deposit is cut by rather closely spaced joints having strikes of N. 45° W. and N. 50° E. According to Mr. L. M. Seawell of the Piedmont Quarries, the granite of this deposit was first utilized in the production of curbstone and small building blocks for local markets, but later the quarry was the scene of considerable crushed-stone production. A thin-section analysis of the medium-grained phase of the rock is:

Quartz	35%
Orthoclase	53%
Plagioclase	2%
Biotite	9%
Others (epidote, zircon, garnet)	1%

On the basis of this analysis, the rock falls into the class biotite granite.

SNYDER PROPERTY

Two abandoned quarries are located on the property of J. W. Snyder, 3.5 miles southwest of Winston-Salem and adjacent to N. C. Highway 150. The older of the quarries covers about one-quarter of an acre and is worked to a depth of about 30 feet. The production from the quarry was made as crushed stone for local road improvement, beginning about 1910. The second quarry, opened about 1920 and worked for a short time by Mr. Snyder, covers about three-quarters of an acre and has been worked to an average depth of 25 feet. When operated, production at the quarry was limited to curbing and small building blocks for local use. Mr. Snyder reports that the method of quarrying dimension stone at the newer quarry consisted of producing a lift sheet over the entire quarry area, using black powder charges and working the lift sheet with plugs and feathers. The granite has fair to poor working qualities.

The granite from both quarries is medium gray in color and ranges from coarse-grained to porphyritic in texture, with the feldspar constituent composing the outsized grains in the rock. Like the granite at the Piedmont Quarry, the rock is highly siliceous and apparently contains about the same mineral composition, however no inclusions were seen in the exposed granite in either of the quarries. A few small binary granite dikes intersect the deposit, and several very small stringers of epidote are present at scattered places in the newer quarry.

THE W. E. GRAHAM QUARRY

The quarry is located three miles north of the corporate limits of Winston-Salem and immediately to the east of U. S. Highway 52. It is developed in a very dark gray to black, thin-bedded biotite gneiss, some 3 to 4 miles away from the gradational granite and gneiss contact. The rock is fine-grained and resembles the biotite-gneiss inclusions contained in the granite at the Piedmont Quarry. The pit-type quarry covers about 1.5 acres and has been worked to a depth of 100 feet. The unweathered rock, which is presently being utilized in the production of crushed stone, is overlain by 30 to 40 feet of dark red residuum.

BASIC DIKES

Diabasic and schistose basic dikes occur in a few scattered localities in the granitic rocks of Forsyth County, being noted in areas lying south and southwest of Winston-Salem. Such intrusions can be seen along U. S. Highway 158, a few miles southwest of the city. Most of the dikes are the small schistose type.

CASWELL COUNTY

The Main Igneous Belt of the Central Piedmont extends across southeastern Caswell County, outcropping through the gneiss-schist complex and in large containing relict structures of the intruded rocks. Within the granite areas, residual overburden attains relatively great thicknesses; consequently, outcrops are limited in both number and size. The production of stone in the county is confined to two quarries, a small State-managed operation, in the contact zone between the granite and metamorphic rocks, and a large commercial quarry, situated well into the granite-gneiss area in the northwestern part of the county. (See Plate III.)

THE PELHAM QUARRY

This quarry, operated by Lambert Brothers, Incorporated, is located at Pelham, 12 miles northwest of Yanceyville, in the extreme northwestern corner of Caswell County. The quarry, formerly known as the Collins Quarry, was reopened in 1946 and has been operated continuously, with its production being confined to various sizes of crushed stone for use as road metal, concrete aggregate, and railroad ballast. The quarry covers approximately 1.75 acres and has been worked to depths ranging from 50 to 150 feet. The most modern equipment is employed, including heavy-duty Diesel trucks, drills, belt conveyers, and primary and secondary crushers.

The deposit in which this pit-type quarry is developed is a flat-surface mass of granite gneiss which has been intricately broken into irregular-shaped blocks, usually of small dimensions. Planes of jointing are, therefore, numerous but could hardly be divided into sets or systems. Sandy, buff-colored residuum covering the fresh rock ranges from 5 to more than 20 feet. The rock is a pinkish-gray, rather fine-grained granite-gneiss, displaying strong parallelism of the principal mineral constituents, quartz, feldspar, and biotite. A thin section, cut from a representative hand specimen, shows the following mineral composition:

Quartz	32%
Orthoclase and microcline	60%
Biotite	7%
Others (chlorite, apatite, magnetite)	1%

According to this analysis, the rock falls into the class biotite granite-gneiss. In thin section, the rock shows a strong gneissic structure with fine mosaics of quartz filling interstitial areas between larger orthoclase and quartz grains. Many of the orthoclase and quartz grains also show complex intergrowth, and the feldspars are slightly sericiticized.

THE STATE QUARRY

The State Quarry in Caswell County is located 6 miles northeast of Yanceyville and 2.5 miles southeast of N. C. Highway 62. The rocks in which the quarry is developed consist of biotite gneiss, biotite schist, muscovite schist, granite-gneiss, and granite pegmatites. The light gray granite-gneiss apparently was derived from the incomplete assimilation of the schistose and gneissic rocks, thus accounting for its gneissic structure. During the intrusive phases of the granite, pegmatitic fluids introduced along the schistosity and cleavage of the older rocks crystallized to form bands of white granitic material. Later, pegmatites have

cross-cut this material. The quarry, a bench-type development, is about 75 feet deep and covers an area of 150 by 200 feet. One prominent joint plane, striking N. 65° E., is common to both the older metamorphic rocks and the granite. Other planes of jointing in the deposit are obscure. The granite, which occurs notably near the floor of the quarry, is a medium-grained gray rock, showing a moderate gneissic structure and containing, in terms of relative abundance, feldspar, quartz, and biotite. Residual overburden, ranging from 1 to 25 feet, overlies highly weathered schists and gneisses, but it is almost entirely absent in the granitic areas of the quarry, the granite showing little signs of disintegration even at the surface.

DAVIDSON, IREDELL AND DAVIE COUNTIES

A portion of the main body of the granitic rocks of the Central Piedmont underlies approximately one-half the total area of Davidson, Iredell, and Davie Counties. Volcanic rocks occupy the southern half of Davidson County, and gneisses and schists largely occupy the northern parts of Iredell and Davie Counties. (See Plate III.) Residual overburden attains relatively great thickness in the entire three-county area, and the scattered small outcrops of granite, excepting those adjacent to major streams, show effects of moderate weathering. As a result of the deep weathering of the rocks, which poses a stripping problem, no commercial granite production is made in the three counties at present; however, some commercial dimension stone was produced near Mooresville, Iredell County, some years ago, and the State Highway and Public Works Commission is producing crushed stone from a small quarry in Davidson County.

STATE QUARRY

The State Quarry in Davidson County is located 9.5 miles south of Lexington and immediately adjacent to the Yadkin River, 1.25 miles west of N. C. Highway 8. The quarry is a pit-type opening, roughly circular in plan, with a diameter of 150 feet and a total depth near 50 feet. The thickness of overburden in the quarry area ranges from less than one foot, near the river, to more than 25 feet just a few hundred feet distant. The deposit is badly fractured by joints having strike directions of north and east. Crushed stone of various sizes is produced at the quarry for use on local secondary roads.

The rock in the quarry area is a light pinkish-gray, massive, medium-grained granite, showing a uniform distribution of the biotite constituent and light pink and gray feldspars in equal amounts. A thin section, cut from a representative sample of the rock, has the following mineral composition:

Quartz	32%
Orthoclase and microcline	37%
Plagioclase	24%
Biotite	5%
Others (calcite, titanite, sericite-muscovite, chlorite)	2%

According to this analysis, the rock is near the composition of quartz-monzonite. A deep pink granite, very similar in physical appearance to this one, may be seen at the Davidson-Rowan county line, near the Yadkin River Bridge on U. S. Highway 29-70-52, southwest of Lexington.

About one-fourth of a mile southwest of the State Quarry area, a small dimension-stone quarry was operated prior to 1927 for the production of paving blocks and building stone of small dimensions. The quarry is developed in an unjointed phase of the granite utilized in the State Quarry.

MOORESVILLE AREA

More than a dozen small quarries were operated in the Mooresville area prior to and for a short time after 1900, the principal openings being the McNeely Quarry, one mile northwest of Mooresville, and the Breed Quarry, located 1.5 miles southwest of Mooresville. The general type of rock in the quarry areas is described by Watson and Laney in the following description of a sample of rock from the Breed Quarry:

> ". . . biotite-granite. . . . Orthoclase and microcline are in nearly equal proportions, with only 1 or 2 grains of plagioclase noted in the section. Biotite . . . is present in large quantity, largely altered to chlorite and a colorless mica."

The rock is fine- to medium-grained, blue-gray granite of uniform texture and color. During the operation of the McNeely and Breed Quarries, most of the production was confined to monumental stock.

DAVIE COUNTY

The granitic rocks of Davie County are similar to those of the Woodleaf area of Rowan County and the light pinkish-gray granite found in Davidson County. Outcrops are limited almost entirely to small areas adjacent to streams. No commercial or noncommercial granite production is made in the county at present.

BASIC DIKES

Dikes of basic composition are rather prevalent over the entire area bounded by Davidson, Iredell, and Davie Counties. Schistose and diabase dikes of basic rock may be seen best along U. S. Highway 29-70, beginning about 3 miles north of Lexington and continuing into the adjacent county. These dikes range in thickness from one inch to more than 100 feet, the larger ones usually showing a pronounced schistose structure. Both the larger schistose dikes and the diabase dikes show minor displacement perpendicular to strike.

MECKLENBURG AND CABARRUS COUNTIES

As shown on Plate III, almost the entire area comprising Mecklenburg and Cabarrus Counties is underlain by granite and related rocks of the Main Igneous Belt, however the commercial development of these rocks never has been attempted on a large scale. At present, the only granite production in the two counties is made in the form of crushed stone at a small State quarry in Mecklenburg County. The lack of commercial utilization of the rocks in this area can probably be attributed to the generally thick residual overburden and the lack of uniformity of physical characteristics of the various rock types.

MECKLENBURG COUNTY

THE CHARLOTTE AREA

Within the present corporate limits and the vicinity immediately adjacent to Charlotte, granite was quarried from several small openings around 1900, but today these openings have been filled or are grown over by vegetation. One such quarry, "The City Quarry," described by Watson and Laney as being the largest opening in the county, produced crushed granite for use on the streets of Charlotte. From the descriptions of other openings in the Charlotte area, the granite from this quarry seems typical of the rocks in the general environs. A microscopic analysis of this stone is given by Watson and Laney, as follows:

> ". . . a biotite granite of a fine textured complexly interlocking aggregate of feldspar and quartz. Potash feldspars, orthoclase and microcline, and microperthitic intergrowths, with very little plagioclase compose the feldspathic constituent. The biotite is irregularly distributed through the section. . . . A few scattered grains of magnetite occur. . . ."

The principal areas in Mecklenburg County in which the granites seem most likely to have potential commercial value are the Charlotte area, the area in and around Davidson in the northern part of the county, and a small area 4 miles south of Newell, a community about 5 miles northeast of Charlotte.

STATE QUARRY

A State-operated quarry, located 9 miles north of Charlotte and 1.5 miles southwest of Huntersville, produces crushed stone for secondary road improvement in Mecklenburg County. At present, it is the only granite operation in the county. The pit-type quarry is developed in rocks of the granite-diorite complex, in which both the granite and diorite units contain well defined schist inclusions and show penetration by basic dikes and stringers of younger epidote and binary granite. Joints, having strikes of N. 40° W. and N. 10° W., break the rocks into blocks of rather small dimensions. Residual overburden in the quarry area ranges from 5 to 15 feet in thickness. The granite, slightly pinkish-gray in color, is an even-granular, medium-grained stone, containing abundant quartz, orthoclase and plagioclase feldspars in about equal proportions, and considerable biotite which tends to segregate. The granite appears to intrude the darker colored diorite.

CABARRUS COUNTY

Except for a few small quarries operated many years ago in the vicinity of Concord, the granites of Cabarrus County have not been worked commercially. Of the many types of granitoid rocks found in Cabar-

rus County, including normal granite of a fine to porphyritic texture, quartz-monzonite, diorite, and gabbro, perhaps the most unusual is a coarse-grained augite-syenite which outcrops in the western part of the county. The syenite is exposed as immense boulders, forming an elliptical pattern, beginning at the village of Harrisburg in southwestern Cabarrus County, swinging northwestward for about 4 miles, turning east for 2 miles, and trending southeast to a point a mile east of Harrisburg. The width of the exposed syenite varies from less than one-fourth of a mile to slightly more than a mile. The "ring" of syenite encloses an area of gabbroic rocks approximately 4 miles in diameter. The syenite is composed largely of outsized grains of potash feldspar, about 15 percent of the ferromagnesian mineral augite, and a minor amount of dark-colored accessory minerals. The overall color of the rock is light bluish-gray. A thin section analysis by Watson and Laney reveals the following mineral composition and physical characteristics of the rock:

> ". . . a coarse-textured, augite-hornblende-biotite syenite composed very largely of feldspar with slight quartz, and the accessories mentioned. The feldspars are orthoclase, microcline, microperthitic intergrowths and subordinate plagioclase (oligoclase). . . . Green augite (diopside) is the principal ferromagnesian silicate. Hornblende of green color exceeds biotite in amount."

This rock was being utilized in the production of ballast about 1903, however no attempt at quarrying it for use as monumental or buiuding stone has been made.

Other outcrops of the granite and related rocks of Cabarrus County are found at widely scattered places, however none are of sufficient importance to be discussed here.

BASIC ROCKS

Basic rocks of both even-granular medium texture and fine-grained dike material have widespread occurrence in Macklenburg and Cabarrus Counties. In Mecklenburg County, basic rocks are most prevalent in areas east of Charlotte and in the vicinity of Davidson. Basic rocks in Cabarrus County are represented by diabase and schistose dikes in widespread areas east and west of Concord and as medium-grained dioritic rocks in the southwestern part of the county.

GASTON, LINCOLN, AND CATAWBA COUNTIES

Rocks of the Main Igneous Belt underlie the central and eastern parts of Gaston County and the eastern portions of Lincoln and Catawba Counties, (Plate III), however no commercial granite has been produced in the area except for minor amounts from a few small openings in the vicinity of Gastonia. These small quarries, operated many years ago, produced small quantities of dimension stone in the form of sills, machinery bases, rough-tooled monuments, and some crushed stone, all of which were marketed in the Gastonia area. Most of the granite was quarried from large boulder and ledge-like outcrops, which are quite common in the central part of the county especially in and around Gastonia and which also represent the largest exposures of workable granite in the three-county area. A thin-section analysis of a typical granite from Gaston County is described by Watson and Laney, as follows:

> "The rock is a biotite granite in which the potash feldspars, orthoclase and microcline, are present in nearly equal amounts. . . . In several of the sections plagioclase failed entirely, while in others only a few scattered finely striated grains were noted. . . . Biotite is of the usual kind and is largely altered to chlorite. . . . The usual microscopic inclusions of apatite and zircon occur."

Most of the granitic rocks of the three counties, especially those noted near their contact with the gneisses and schists to the west, show some parallel growth of the mafic constituent and some evidence of recrysallization of quartz.

OTHER COUNTIES

Other counties in the Central Piedmont in which granite and related rocks occur include Alamance and Person, both of which are of little importance relative to the production of commercial or noncommercial granite. Rockingham County, in the northern part of the Central Piedmont, lies entirely out of the Main Igneous Belt but has been an important producer of crushed stone in the past, the production coming from a quarry developed in a siliceous gneissic rock.

ALAMANCE COUNTY

Most of the granitic rocks of Alamance County are complexly associated with rocks of the Volcanic-Slate Series, into which they were emplaced; and, in turn, this complex has been intruded by large dikes of basic rock and innumerable small aplite dikes. The decay of the granite and associated rocks has progressed to such an extent as to render outcrops of fresh rock rare, except along major drainage. A thin section, cut from one such outcrop of a medium-gray, large-grained granite exposed along Reedy Fork Creek in the village of Ossipee in northwestern Alamance County, shows the following mineral composition:

Quartz	20%
Orthoclase	51%
Plagioclase	17%
Biotite	8%
Others (mostly epidote with minor amounts of apatite, magnetite, and sericite)	4%

This analysis indicates that the rock is near the composition of normal granite, however it is apparent that it has suffered considerable alteration as manifested by the large amounts of epidote included in the mineral composition. Of considerable interest in the examination of the section was the abundance of zoned plagioclase feldspar. Prior to 1906, the granite from this ledge-like outcrop along the creek was worked to supply rough building stones in the immediate vicinity of Ossipee and Altamahaw.

PERSON COUNTY

The production of granite in Person County has been limited to one large State-operated quarry, located one-half of a mile east of Roxboro. At present, the quarry is abandoned. This quarry, a bench-type opening, is developed in a light pinkish-gray, mostly large-grained granitic rock deposit, which forms a rather prominent topographic rise trending north for a distance of approximately a thousand feet. The rock shows signs of considerable shear, being broken into small irregular blocks by planes of jointing, striking N. 42° W., N. 10° E., N. 77° W., and N. 33° W. Sheeting planes at intervals of about one foot are well developed over the entire quarry, which covers an area of about one-half of an acre and has been worked to a depth of 40 feet. Residual overburden in the quarry area ranges from 1 to 15 feet in thickness. The rock body contains many small quartz veins and numerous inclusions of dark volcanic rock. Orthoclase feldspar is the principal constituent of the rock, followed in abundance by the included volcanic rocks, quartz, and biotite.

ROCKINGHAM COUNTY

Some years ago, large amounts of crushed stone were produced at a quarry developed in siliceous gneiss near the village of Stacey, in east-central Rockingham County. This quarry, now abandoned, offers an excellent opportunity for further development, especially at the north end where water has not flooded the opening. The rock is a hard, well bedded, highly siliceous gneiss containing abundant quartz, much feldspar, small amounts of biotite, and scattered dark accessory minerals. The deposit is strongly sheared.

GRANITES OF THE WESTERN PIEDMONT

The Western Piedmont division of the Piedmont Plateau is mostly underlain by pre-Cambrian gneisses and schists, penetrated in some places by granitic rocks which tend to form narrow northeast trending belts. Sedimentary rocks of Triassic age occupy relative lowlands in parts of Stokes, Davie, and Yadkin Counties, in the northeastern part of the region. The area comprising the Western Piedmont is bounded on the east by the Main Igneous Belt of the Central Piedmont and the eastern line of Stokes County; on the west, by the Blue Ridge escarpment, and by Virginia and South Carolina, respectively, on the north and south. (See Plate IV.)

Outcrops of granite in the Western Piedmont generally are limited to scattered boulders and flat-surface outcrops; however, several large "stone mountains" stand as barren granite monadnocks, especially in the northern half of the division. Residual decay in the granite areas is similar in composition and color to the

material of the other granite regions of the State and is equally as thick. All, or a portion, of 17 counties comprise the Western Piedmont area, including the present or former granite and granite-gneiss producing counties of Surry, Wilkes, and Yadkin. At present, commercial granite production is limited to the famous Mt. Airy quarries, the largest single dimension-stone operation in the State and among the largest and most modern in the Nation. The granite potential of this region can be considered unlimited. However, the massive character of the granite will constitute much difficulty should quarrying operations for crushed stone be undertaken in some areas.

SURRY COUNTY

The principal occurrences of granite in Surry County form two narrow belts, trending northeast, across a part of the eastern half of the county. The remainder of the county is underlain by various types of gneisses and schists, which contain numerous small pegmatitic intrusives and a few small diabase dikes. In the igneous belts, the largest of the rather scarce outcrops of granite occur as boulders and low flat-surface masses, showing most often an advanced stage of decay which renders the stone useless as a source either of crushed or dimension granite. The notable exception to the deep weathering exhibited by the granites is the immense, gently sloping outcrop of fresh granite exposed for about five thousand feet along the crest of a rather conspicuous hill, one mile northwest of Mt. Airy. Quarrying on an extensive scale has been carried on in this area continuously since 1904 by the North Carolina Granite Corporation and for 15 years prior to that time by Thomas Woodroffe and Sons and The Mt. Airy Granite Company.

THE NORTH CAROLINA GRANITE CORPORATION (MT. AIRY QUARRIES)

The quarries of the North Carolina Granite Corporation are located over an area covering more than a hundred acres atop and on the gentle slope (12°) of a large dome-like outcrop of unjointed, slightly gneissic granite, having areal dimensions approximating one mile by one-half of a mile. The quarries consist of several working areas devoted exclusively to the quarrying of dimension stone and one large area in which stone is quarried for crushing in a plant equipped to produce poultry grit from the stone.

The dimension-stone areas at Mt. Airy, unlike other dimension granite quarries in North Carolina, have very little depth from the top surface of the granite to the working surface. This type quarry development has resulted from the working of layers, or sheets of granite separated from the main mass by the induction of sheeting planes at 6, 8, or any desired number of feet below the surface of the rock body and working these layers of granite until exhausted. Quarry development such as this is greatly facilitated by the gentle slope of the rock from the uppermost outcrop area to the base of the exposure. In the case of the Mt. Airy quarries, lift sheets, or layers, of granite are produced by cleaving the stone at a depth below the surface comparable to a desired thickness of the rough block and splitting along vertical planes, using feathers and wedges, to the desired horizontal dimensions. Rough blocks are hoisted onto quarry cars for removal to the cutting and finishing sheds. After a complete lift sheet has been worked off, another may be produced in the same area and worked similarly. Each quarry may produce blocks of varying widths and uniform thickness, so that, an order for stone of a desired width are available for transport to the cutting sheds for custom splitting into blocks of less thickness than those quarried. Thin slabs of granite also may be produced at the quarry from a lift sheet of less thickness than the usual 6 or 8 feet. This method of quarrying sheets is essentially one of peeling off layers of granite as needed. The creation of artificial sheeting planes, or bottom joints, in the Mt. Airy quarries will be discussed in the section of this report concerned with quarrying.

The blocks of granite from the several quarries are cut, surfaced, and finished in plants located at the base of the granite hill. These plants, among the largest and most modern in the Nation, are capable of turning out granite in any form, polished or rough-cut as the market demands. Some of the various equipment available for finishing the granite are gang and diamond saws of the latest design, surfacing machines, contour machines, automatic polishers, and precision instruments employed in the shaping of statues and memorials of various designs. (See Figure 4.) The principal dimension-stone products from the Mt. Airy quarries include mausoleums, bridge construction stones, statues, architectural stone, and curbing. Of these products, the company leads the Nation in output of mausoleums, ranks second in the production of bridge construction stones, and is a leading producer of the other products, especially architectural stone and cus-

tom-made curbing. Production figures furnished by Mr. J. P. Frank, president of the company, show that 3,600 carloads of granite were shipped from the quarries in 1952. This figure includes 1,200 carloads of poultry grit of the various sizes produced at the company's crushing plant. In comparison with the 1952 production, 135 carloads of granite were shipped from the quarries in their first year of operation during the year 1889 to 1890.

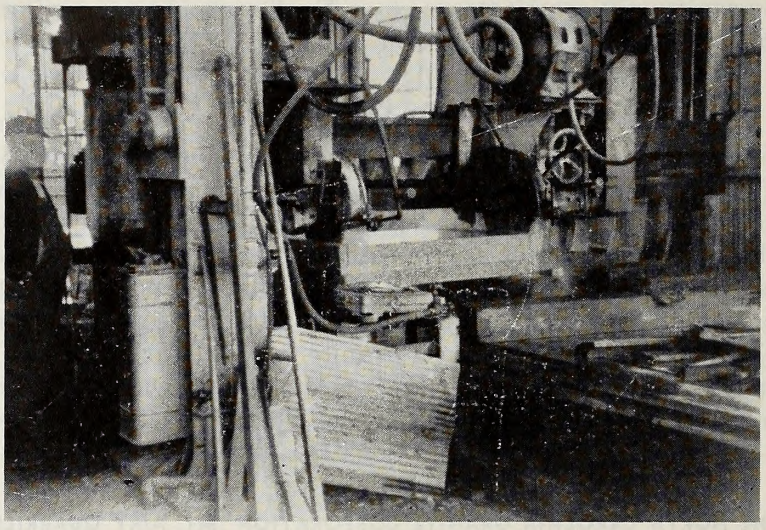

FIGURE 4. CUTTING GRANITE WITH DIAMOND SAWS, MT. AIRY QUARRIES, SURRY COUNTY

The crushed-stone quarry is much the same as other bench-type quarries in North Carolina. Granite is dislodged from the walls of the quarry by dynamite charges, set into drill holes of large diameter. Shots are detonated in milli-second, delayed-action sequence to produce the best possible fragmentation. Large blocks of stone remaining after a shot are reduced to the desired size by the use of a one-ton, drop-ball setup. This method of secondary fragmentation has proved a most effective and time-saving method at Mt. Airy and could well be put into use in other crushed-stone quarries across the State. The broken stone is moved by truck to a well equipped crushing plant, a few hundred feet from the quarry, and fed into crushers. From the crushers, the stone moves through a series of screens of various sizes, designed to retain the crushed granite in the five-size classes in which the rock is sold as poultry grit. The crushed granite, sacked and sold under the trade name of "Grani-Grit," has found a large market in many parts of the United States. Crushed stone from this plant is also marketed as concrete aggregate.

Mt. Airy granite is a very light gray to almost white, medium-grained stone, composed of much feldspar, quartz, biotite, and exceedingly small amounts of apatite, zircon, and epidote. Except for the biotite, which tends to segregate, the mineral constituents of the granite are distributed very uniformly, thus presenting a stone of unusual beauty and adaptability. This stone is widely known as a white granite and has found many uses for which hard, durable stones of light color are desired. A thin section, cut from a representative sample of Mt. Airy granite, shows the following mineral composition:

Quartz	26%
Orthoclase	32%
Plagioclase	23%
Biotite	8%
Others (apatite, zircon, muscovite, chlorite, and epidote)	1%

In thin section, this stone, a quartz-monzonite, shows a slightly gneissic structure, minor kaolinization of the feldspar constituent, and some grains of microperthite. A chemical analysis of the stone may be seen on page 3, in column 4 of Table I.

OTHER AREAS

Granite occurs in other counties of the Western Piedmont in much the same manner as in Surry County; however, it is more or less gneissic, depending upon the degree of pressure metamorphism to which the rock bodies have been subjected or the degree to which the structures in the intruded gneissic rocks have been

retained by the granite. Notable areas of granitic rocks in the Western Piedmont include: (1) parts of the northern third of Stokes County, (2) a narrow area across central Yadkin County, (3) an elliptical-shaped area in Cleveland County which extends into northwestern Gaston County, and (4) an elongated body of granite underlying parts of southeastern Polk County and southwestern Rutherford County. (See Plate IV.) Smaller areas of strongly gneissic granites underlie parts of Wilkes, Catawba, Caldwell, and Alexander Counties. In most of the above areas the granitic rocks are broken into small irregular blocks by profuse jointing and are usually overlain by great thickness of residual soil.

Residual masses of granite or granite-gneiss, often called "stone mountains," are rather prominent in the Western Piedmont. Two of the largest are described by Watson and Laney, as follows:

> Alexander County: "Rocky Face Mountain, which is located about 6 miles northeast of Taylorsville, . . . is an elongated dome-shaped mass of granite-gneiss rising to an elevation of not less than 500 feet above the surrounding plain and measuring about 4 miles around the base . . . a residual of biotite granite-gneiss of light gray color and medium texture made up of alternating dark and light colored layers. . . . The banding is of irregular thickness though generally averaging thin. . . . The strike of the joint planes observed was N. 30° E. and N. 80° E."

According to the thin-section analysis of this stone, it is a biotite granite-gneiss.

> Wilkes County: "Stone Mountain, the most prominent one of the granite residuals, is an oval shaped mass of granite, 500 to 600 feet high and measuring 3 to 4 miles in circumference, at the base. . . . The rock is a light gray, nearly white, medium-grained, biotite granite of slightly coarser texture than the Mt. Airy granite in Surry County, which it closely resembles in color and other properties . . . it shows a few segregated areas of black biotite, which become somewhat frequent in certain portions of the rock. . . . Like the Mt. Airy granite, it is nearly free from joint-planes, not more than half a dozen joints being observed in the entire residual. These had a strike of N. 45° E. and N. 45° W."

Other residual granite masses somewhat smaller than those described above are located along the boundary line between Wilkes and Alleghany Counties. These masses retain the oval shape of the "stone mountains" and appear to have mineral compositions similar to the larger residuals. The "stone mountains," although representing large volumes of granitic rock, are unsuited for quarry development of any type. The rather steep slopes of the "mountains" and the general lack of uniformity of color and texture render the rocks useless as a source of high-quality dimension stone, while the massiveness of the rock bodies dismisses them as good sources of stone for crushing.

Some commercial quarrying for crushed stone has been conducted in the past in the vicinity of North Wilkesboro, Wilkes County; Hickory, Catawba County; and Yadkinville, Yadkin County, in areas underlain by granite-gneiss, however no regularly operated quarries are known in these areas at the present time. From time to time, the North Carolina State Highway and Public Works Commission utilizes granite-gneiss in the production of crushed stone in some parts of the Western Piedmont, but these operations are usually small and of a temporary design.

GRANITES OF THE BLUE RIDGE

The Blue Ridge, smallest and westernmost physiographic division of the State, contains several granite and granite-gneiss areas, however no commercial granites are produced in the region at present. The principal granite and granite-gneiss bodies, representing a rather complete penetration of older gneisses and schists, underlie parts of Transylvania, Jackson, Macon, and Clay Counties. Like the granite areas in the other regions of the State, these bodies tend to form more or less narrow belts which lie along northeast-southwest trending axes. Other granitoid rocks are found in several other counties in complex association with older metamorphic rocks, but these occurrences are of little significance in a report of this type. An interesting large-grained to porphyritic granitic rock, or "alaskite," underlies a rather extensive area of Mitchell and Yancey Counties and is utilized extensively in the ground feldspar and mica industries in that section. This rock has been classified mineralogically as a "leucogranodioritic fine-grained pegmatite" by Parker, (p. 9, 1952).

Gneisses and schists of the mica and amphibole types are the most abundant rocks in the Blue Ridge, at times being important in the production of crushed stone. However, natural gravel from flood plains and

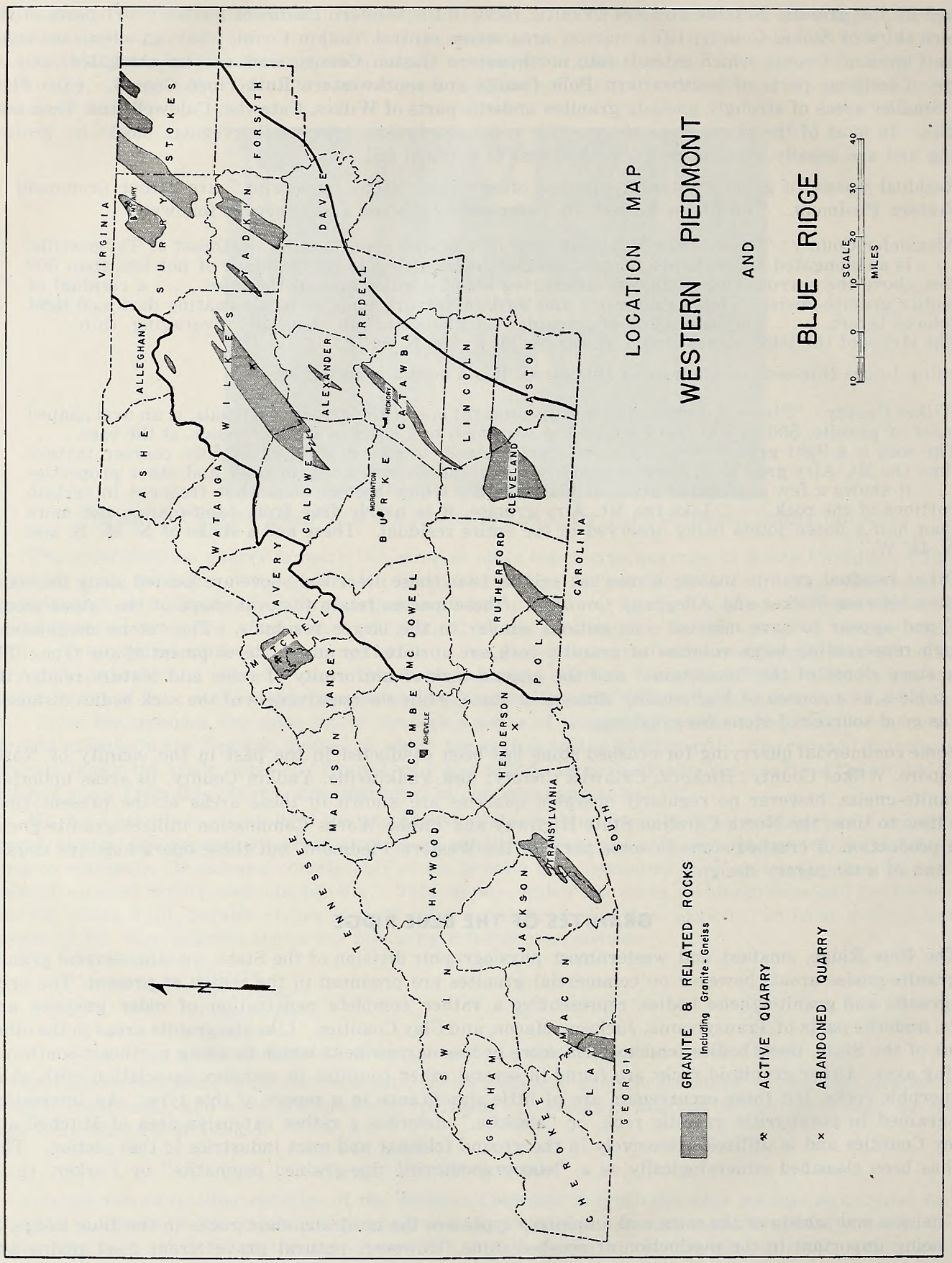
LOCATION MAP
WESTERN PIEDMONT
AND
BLUE RIDGE
SCALE
MILES
GRANITE & RELATED ROCKS
Including Granite-Gneiss
ACTIVE QUARRY
ABANDONED QUARRY
VIRGINIA
TENNESSEE
SOUTH CAROLINA
GEORGIA
ASHE
ALLEGHANY
SURRY
STOKES
FORSYTH
DAVIE
WILKES
YADKIN
IREDELL
ALEXANDER
CATAWBA
WATAUGA
CALDWELL
BURKE
LINCOLN
GASTON
CLEVELAND
AVERY
MITCHELL
MADISON
YANCEY
MC DOWELL
RUTHERFORD
POLK
BUNCOMBE
ASHEVILLE
HENDERSON
TRANSYLVANIA
HAYWOOD
JACKSON
SWAIN
GRAHAM
MACON
CHEROKEE
CLAY
MORGANTON
HICKORY
N

PLATE IV

intermittent stream channels and crushed limestone from several quarries are utilized largely as aggregates and road metal because of the comparative ease in obtaining the materials. Other rock types, quarried on a minor scale in the region, include quartzite, slate, and shale.

Since rocks of the massive granitic type are relatively rare in the Blue Ridge, the unlimited amounts of metamorphic rocks offer the largest and most available sources of stone for use either as dimension or crushed stone. In many places these rocks are sound and of a color requisite for use as dimension stone, especially for rough construction and bridge building, and the availability of stone for crushing is equally as favorable. Quarries utilizing gneisses or schists have been operated in Buncombe and Henderson Counties, but none are known to be operating at the present time.

Due to the lack of commercial granite production in the Blue Ridge, a minimum of work was done in the region, and most of the following data were compiled from the report by Watson and Laney and folios published by the United States Geological Survey. Only the more important occurrences are described, and they, very briefly.

Swain County: A medium- to coarse-textured, light gray biotite granite-gneiss is exposed 1.5 to 2 miles west of Bryson City along the deeper railroad and highways cuts. This gneissic rock, distinctly intrusive into mica schist, shows a lineation of the mineral constituents in a direction opposed to that of the schist. According to a thin-section analysis, the rock has a mineral composition comparable to normal, or biotite, granite-gneiss. The deposit may prove of some value as a source of stone for crushing.

Henderson County: An abandoned quarry, covering about a quarter acre, located 1.7 miles north of Hendersonville and 0.5 of a mile east of U. S. Highway 25, has been developed in an unusual augen-gneiss of a mineral composition approximating granite. This distinctive rock type underlies a rather extensive area in central and southern Henderson County and parts of eastern Transylvania County. It is a medium gray, medium-grained granite-gneiss, containing large, elongated (elipsoidal) phenocrysts of potash feldspar lying parallel to the well developed schistosity. The quarry was formerly operated for the production of railroad ballast, but blocks of stone 4 by 8 by 10 feet are reported easily quarried and to have good splitting qualities. A stone such as this would be admirably suited to interior or exterior dimension work wherever unique stone is required.

Transylvania County: Granitic rocks showing strongly gneissic structure are exposed in several scattered localities along the western boundary of Transylvania County but are not known to be worked in any locality at present. Considering the irregular character and complex jointing of these rocks, it is doubtful that they can be utilized except as a source of stone for crushing.

Clay and Macon Counties: Small areas of Clay and Macon Counties are underlain by granite-gneisses, forming a narrow belt trending northeast across a part of these counties. The principal rock type is a typical fine-grained, light gray biotite-granite gneiss, varying from slightly gneissic to extremely schistose. Jointing is fairly well developed and often widely spaced. This rock may prove useful as a source of crushed stone in some areas should market demands merit its exploitation.

Other Areas: Other less notable areas of granite and granite-gneiss occurring in the Blue Ridge are found in Madison County near Hot Springs, the southern part of Jackson County, and parts of Watauga and Ashe Counties; however these rocks are most often complexly intercalated with older gneissic and schistose rocks and will, therefore, prove of little or no commercial value.

PROSPECTING, EXPLORATION, AND QUARRYING

DIMENSION STONE

In prospecting for granitic rocks of dimension-stone quality, it is advisable to consider the conditions of occurrence, as follows: (1) size and shape of the deposit, (2) topographic expression, (3) spacing and frequency of joints, including sheeting planes, (4) overburden and depth of weathering, and (5) uniformity of texture and color.

PROSPECTING AND EXPLORATION

Size of Deposits: Magmas, from which granites and related rocks are derived, are intruded from unknown depths into the crustal portion of the earth in large masses, so that outcrops and shallow-lying bodies of granite represent the parts of deep-seated intrusions implaced into portions of the crust nearest the surface of the earth. Therefore, any outcrop, regardless of areal extent, can be considered generally as bottomless, and stone can be removed from a deposit so long as it is economically feasible to quarry.

Topography: The topographic expression, or attitude, of a rock deposit often influences greatly its value as a potential source of commercial stone. Broad, flat occurrences of granite necessitate vertical descent into the deposit and a horizontal expansion of the initial opening. Openings of this type are referred to as pit quarries, and production from this type of quarry in most instances is expensive or even prohibitive, due to a delayed and smetimes low return from original investment.

Many granite deposits occur as dome-shaped masses, rising above the general level of the surrounding terrain and permitting the development of wide, shallow quarries with easy access and natural drainage. In rock masses displaying the dome-like attitude, the production of stone is facilitated without working downward from the surface. Generally, openings are made in any flanking face of the "dome" and worked more or less horizontally and to a much lesser extent vertically. Such developments are called shelf or bench quarries and are seldom deep unless restricted by property lines or by improvement of the rock at depth. Figure 5 shows a cross section of a pit-type and a bench-type quarry.

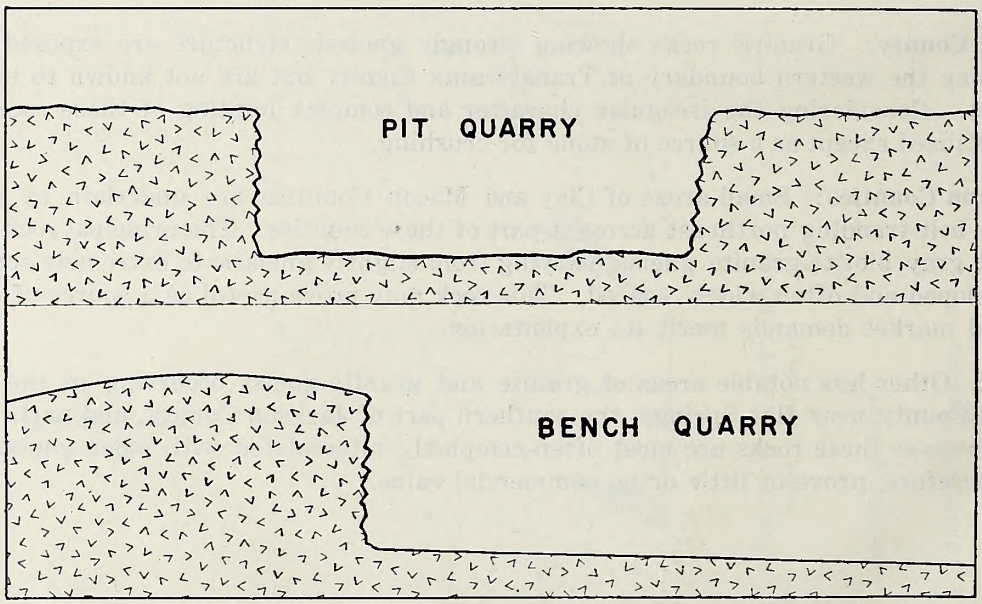

FIGURE 5: IDEALIZED CROSS SECTION OF PIT AND BENCH-TYPE QUARRIES

Joints: The position and direction of quarry walls is, in most instances, governed by the joint systems. A prominent joint plane usually constitutes a heading, or quarry wall, along which the initial opening is deepened and expanded horizontally. The joint systems at right angles to each other constitute the ideal condition necessary for the development of a rectangular-shaped quarry, and dimension stone taken from

such a quarry is itself roughly rectangular. Blocks of geometric shape are tooled more easily; thus, the development of a quarry facilitating the production of rectangular blocks aids in the lowering of operating costs. The spacing of both vertical and bottom joints determines the thickness of dimension stone and should be considered critically in prospecting for dimension-stone quarry sites. A close spacing either of the vertical or bottom joints dismisses from consideration a deposit for quarrying dimension stone of large size. Likewise, the absence of extremely wide spacing of joints may render the deposit unusable unless the stone is of exceptional quality. Sheeting planes 10 to 30 feet apart and vertical joints 10 or more feet apart are considered ideal for dimension-stone quarrying.

Overburden: In most granite-quarrying areas in North Carolina it is necessary to remove residual overburden preparatory to producing dimension stone. The decayed rock is removed by mechanical methods, including dragline scrapers or excavators, power shovels, and tractor excavators. Hydraulic methods can be used if sufficient water is available and the site is provided with favorable waste-disposing areas, affording natural drainage. Completely decayed residual overburden ranges from less than one foot to 20 or more feet in thickness and is generally underlain by partially decayed rock unsuitable for marketing. This material must be removed by hand methods or carefully controlled blasting.

Color and Texture: Color and texture in granite deposits should be consistent both laterally and vertically in order to assure uniformity in the marketed product.

QUARRYING

Present-day methods employed in the separation of large blocks of granite from the quarry wall and further subdivision of the large masses are varied and are discussed here in a general way. Specific alterations in the general procedures as used in North Carolina quarries are mentioned in the descriptions of individual quarrying areas.

In the separation of blocks of granite from a deposit or into stones of smaller dimensions, one of two methods—blasting or wedging—is generally used. In the separation of a block from the quarry wall by blasting, small diameter shot holes are drilled to a depth slightly above the sheeting plane and along a straight line for the linear distance desired. The spacing of the holes is determined by prior experience, but they are normally drilled a foot or two apart. The holes are charged slightly with black powder, tamped lightly, and detonated simultaneously. The simultaneous exploding of the powder charges results in an even distribution of the shot through the stone. Care must be taken during the separation to use the exact amount of powder necessary for the fracture, since use of an excess of the explosive may cause a shattering of the block or a weakening of it by the creation of microscopic or incipient fractures. The shot holes for this type breakage are drilled with pneumatic drills, and a reaming tool is sometimes used to cut grooves in the shot holes in line with the direction of desired splitting to facilitate the fracturing.

In most quarries the use of powder for the separation of block granite has been replaced by mechanical wedging methods. The most common of these methods or techniques is known as plug and feather wedging. The tool used to accomplish the separation consists of two half-rounded steel bars, called feathers, on each side of a hard steel chisel, known as the plug, extending above the feathers. A break in granite is produced, using this method, by drilling a series of plug holes 4 to 6 inches in depth and 6 to 18 inches apart along the line of desired fracture, using a hard steel bit. Plug and feather tools are then placed into the holes and the plugs are struck successively until the wedging pressure of the feathers is sufficient to produce a failure in the stone. Usually, a little time is allowed between the sledging of the plugs for the pressure exerted by the feathers to be distributed evenly along the line of holes. Well developed rift and grain aid immeasurably in plug and feather fracturing, and fortunately the rift usually parallels the major joint system along which the opening is developed in granite deposits. Figure 6 shows the setup of a plug and feather wedge preparatory to splitting. If it is desirable to produce a break parallel to the hard way (against rift or grain), "foot" holes 1 to 1½ feet deep are drilled between plug holes 1½ to 4 feet apart and the same procedure used as in "rift" fracturing.

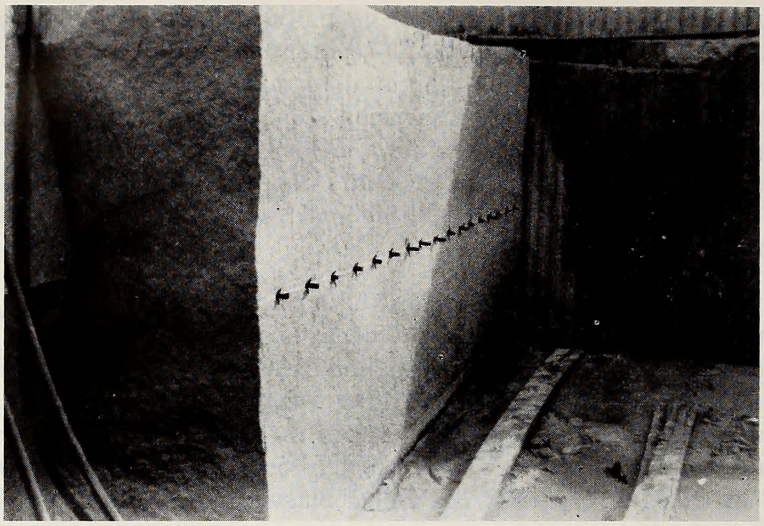

FIGURE 6: PLUG AND FEATHER SPLITTING OF GRANITE
(J. A. Logan Quarry, Faith)

A method known as broaching or channelling also is used for making breaks in granite against rift and grain. This method involves the drilling of closely spaced holes along the poposed line of fracture, using a quarry or channel bar equipped with a rounded, hard steel drill. The holes are usually about 2 inches in diameter and are drilled vertically until they intersect the sheeting plane. The undrilled granite, or webs, remaining between the holes is removed by replacing the rounded bar with one terminating in a wedge and drilling the webs vertically to the point of intersection with the sheeting plane. The second step completes the separation of the block from the quarry wall. Figure 7 shows a quarry or channel bar in a working position.

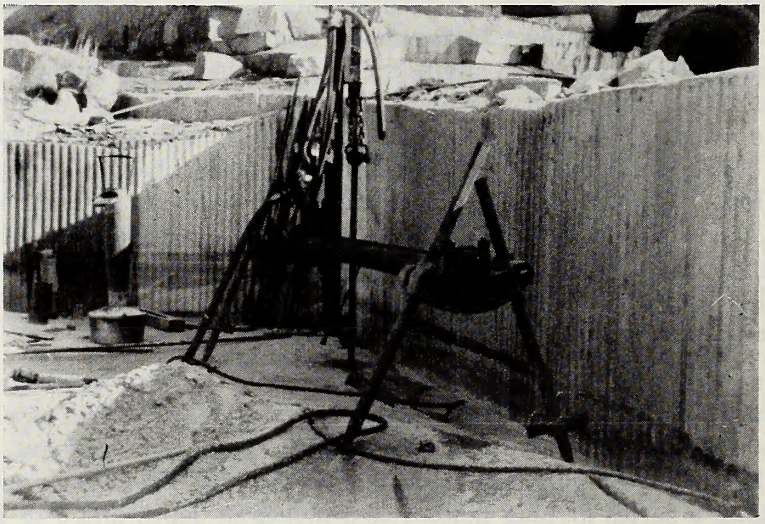

FIGURE 7: CHANNEL BAR IN WORKING POSITION
(J. A. Logan Quarry, Faith)

Large thin blocks of granite are obtained by drilling a line of holes 6 inches apart to almost the full depth of the desired block and using plugs and feathers and channel bars in the same manner as described above.

In the absence of natural sheeting planes, the vertical thickness of granite is determined by artificial breaks in the granite, accomplished by using the lift method. An artificial sheeting plane or lift is produced in the following manner: In the approximate center of the sheet to be lifted, a 2- to 3-inch diameter hole, called the lift hole, is drilled to a depth of 6 to 10 feet, depending on the maximum thickness of stone required, and small amounts (½ to 1 lb.) of black powder are successively detonated in the bottom of the

hole until a crack is extended for a distance of 75 feet, more or less circumferential to the hole. A pipe is then cemented into the hole and air, compressed to 70- to 80-pound pressure, is gradually admitted until the crack is extended in all directions and appears at a point on the slope surface of the deposit. A peripheral break of say one acre requires about half an hour as against 10 to 12 days for an equal extension of the crack using powder charges. Care must be taken during the process to control carefully the induction of compressed air into the cavity; otherwise, suddenly increased pressures will turn along a vertical plane of weakness in the rock and come to the surface prior to the lifting of the sheet over the desired area. The use of compressed air in the extension of the powder-produced, artificial sheeting plane is not always necessary, especially during the hottest of the summer months. During the cleaving procedure in the summer, the weight of the overlying granite, attempting to attain gravity equilibrium by sinking into the powder-produced cavity, exerts sufficient horizontal strain or lift action in the granite to extend the crack naturally. For reasons unknown but perhaps through the aid of natural expansion of the rock in response to heat, the production of a sheeting plane by the described method is best accomplished during the summer months. It is doubtful that a sheet would cleave during extremely cold weather. Lifts over small areas are completed entirely by the use of black powder and usually cover only 1,000 to 2,000 square feet. Subdivision of the lifted sheet is done by the plug and feather method, as described above.

Removal of Stone from Quarry: The removal of dimension stone from the quarry, or the transfer to spur railroad or motor trucks, is accomplished by the use of derricks equipped with steam or electrically operated hoists. The derricks are constructed either of steel or wood and are generally capable of handling blocks weighing up to 50 tons. Electrically powered steel derricks are in general use in the dimension-stone quarries of North Carolina.

CRUSHED STONE

A plan for prospecting and exploration for crushed stone sources can be carried out in much the same fashion as one for dimension stone, though physical and structural requirements of deposits are much less rigid. Critical analyses of size, shape, topographic expression, and overburden are parallel requisites. The spacing and frequency of joints are considered in a different manner, and color and textural properties are of little significance. Joints serve to best advantage when closely spaced and free from filling by fine-grained residual or clastic material, which operates as a cushioning medium to the shot. A close spacing of open joints facilitates good fragmentation at a minimum expense, thus preventing time-consuming secondary fragmentation. Quarries either of the bench or pit types developed in highly jointed rock deposits are called boulder quarries, and most crushed stone operations are developed in such areas.

The presence of widely spaced vertical joints is as detrimental in crushed stone quarry operations as closely spaced ones in dimension-stone quarries. Widely spaced fractures necessitate an increase in the use of blasting powder for primary fragmentation, and an additional increase in cost may be incurred for secondary shooting of large unbroken blocks. Large blocks of stone remaining after the initial shot are reduced further in size by "adobe" shooting, "block-holing," or the drop ball. Block-holing is used most frequently in North Carolina quarries, although it is generally more expensive than the adobe or the drop-ball methods. It is accomplished by drilling one or more small-diameter holes with hand-held drills and detonating a powder charge in each hole.

Perhaps the prime economic consideration in crushed-stone exploration and quarrying is the proximity to market. Seldom, if ever, are the physical and structural characteristics of any rock deposit ideal for the development of the deposit, but a nearness to market and a perennial demand for crushed stone frequently offset the increased costs in the quarrying of rock of otherwise undesirable occurrence.

For successful operation, the type of quarry development for the removal of stone for crushing should be similar to the most efficient in dimension-stone quarrying. Generally, openings are made into "domes," deepened vertically for 50 to 200 feet, and worked horizontally until restricted by property lines. The rather rapid deepening of a crushed-stone quarry is necessitated by the removal of large tonnages in a comparatively short time and the need for high quarry faces from which to dislodge large amounts of rock to feed continuously operating crushers. In the shooting of characteristic steep faces in rock quarries, several rows of holes—either parallel or staggered—are drilled to depths slightly below the floor of the quarry, charged with

powder of great strength, and detonated either simultaneously or in milli-second, delayed-action sequence. Shot holes of fairly large diameter (6 to 9 inches) produce the most desirable fragmentation. Blasting methods for the dislocation of stone are varied and generally are applied to meet local conditions. For this reason, differences in physical properties of granites necessitate the use of standard methods coupled with specific alterations in crushed-stone quarries in North Carolina. For details of blasting procedures used in quarries, the reader is referred to the many handbooks regarding the use of high explosives.

THE TESTING OF GRANITE

DIMENSION STONE

Granite is among the most enduring of all building materials. Structures built of granite many centuries ago are still in good condition and should withstand successfully the detrimental effects of weathering for many centuries to come . Testing of the enduring qualities of granites is best accomplished by observing the stone year after year during which time it is exposed to the naturally destructive effects of weather. Because this is impractical, various methods have been devised for the testing of stone whereby natural weathering processes are duplicated as closely as possible and accelerated in the laboratory. The most important of these tests is concerned with the effects on stone subjected to frost action and the chemical reactions produced by slightly acid waters, such as, rainwater and fog.

Granites are porous to some extent. Tests have shown that medium-grained granites contain pore spaces equal to one-tenth of one percent to as high as five-tenths of one percent of the total volume of the stone (Meinzer, 1923). Water infiltrating the usually subcapillary sized voids is in large part trapped and remains essentially as a permanent pore filling. The repeated freezing and thawing, expansion and contraction, of the contained water results in the development of incipient fractures and a subsequent enlargement and increase of the pore spaces within the stone by wedging of the mineral grains along cleavage planes and grain contacts. During periods of thawing, part of the trapped water may be released from the enlarged voids, but additional water reenters the pores, and the wedging action of freezing water is repeated. The enlargement resulting from the expansion of the liquid in the subcapillary voids also produces increased surface areas upon which waters can perform solvent action, and the feldspar constituents, together with any undesirable accessory minerals (iron sulphides, etc.) present in the rock, will undergo chemical decomposition. The solvent action upon these minerals is reflected by the overall weakening of the stone, by chemical disintegration, and the production of unsightly iron oxide and other stains derived from the alteration of sulphide and iron oxide accessory minerals. It is interesting to note that granite in its natural state contains about 8 percent of water and is capable of absorbing 2 percent more; therefore, a cubic yard of granite contains approximately 3.5 gallons of water and will absorb about nine-tenths of a gallon more.

The duplication of frost action is accomplished in the laboratory by saturating a test block of stone in a sodium sulphate solution at a temperature of 70° F. for a predetermined time, followed by a period of drying at 110° C. This test produces results corresponding to the action of alternate freezing and thawing. Some tests duplicating frost action require a deep freezing of the material followed by thawing at room temperature, but tests of this type are not standardized.

Unweathered granite is a very strong material. Crushing strengths ranging from 18,384 to 22,469 pounds per square inch are encountered in the granite of the Mt. Airy district, and stone of related composition in Rowan County is believed to possess equal strength. It will be noted that ordinary stone construction requires crushing strengths of 6,000 or more pounds per square inch; so, the dimension granites of North Carolina compare favorably and even exceed the strength required in any type of construction. The determination of crushing strength is accomplished by the use of specially constructed pressure machines into which are placed cubes or cores of the stone to be tested.

Other tests of relatively minor importance include those devised for the determination of ratio of expansion and contraction, elasticity, resistance to shearing forces, fireproof properties, and color changes. For a discussion of the tests and the various testing media and machines, the reader is referred to the publications of the American Society for Testing materials.

CRUSHED STONE

The most common tests performed for the determination of the wearing and lasting properties of crushed stone include hardness, toughness, and soundness.

Hardness: The hardness of stone is expressed as a coefficient value and is sometimes obtained by subjecting a core of the rock one inch in diameter to the abrasive action of a revolving steel disk over which crushed quartz sand (30-40 mesh) is passed. After 1,000 revolutions of the disk, the loss in weight (w) of the rock core is determined and the hardness factor obtained by the formula 20-w/3. In recent years, however, the Los Angeles abrasion test has replaced this and other tests made for the determination of hardness of crushed stone. The Los Angeles abrasion machine consists of a steel drum 28 inches in diameter and 20 inches long, mounted so that rotation is around the long axis of the drum. A radial shelf about 4 inches wide extends from end to end inside the drum. For the test 5,000 grams of sized crushed aggregate with 12 steel spheres weighing 390-440 grams each are placed inside the drum and rotated 500 revolutions at the rate of 30-33 rpm. At the end of the test, the loss due to abrasion is determined by rescreening the original sample and computing the percentage of loss as related to the weight of the original aggregate sample. Such a test as that briefly described above is called the A abrasion test and is usually followed by the B and C tests during the comprehensive testing of aggregates. The Los Angeles abrasion tests are accomplished in the same machine but are independent determinations. Each requires a multi-sized aggregate and steel spheres of different total weights. Both the sizes in the aggregate and the steel spheres used are based on established standards. Results of Los Angeles abrasion tests of North Carolina granites from various localities are given in Table III.

Toughness: Toughness as defined in a preceding section of this paper is determined by subjecting a core of rock one inch in diameter to the impact of a 2-kilogram hammer, falling from successively increasing heights of one centimeter until the core fractures. The height in centimeters through which the hammer is required to fall for fracture is taken as the toughness value for the rock.

TABLE III. RESULTS OF LOS ANGELES ABRASION TESTS ON SOME NORTH CAROLINA GRANITES

Name of Quarry	*Type of Test* A	B	C	*Location*	*Rock Described Page*
Balfour Quarry	25	26	31	Rowan	29
Grassy Creek Quarry*	27	29	31	Granville	24
Greystone Quarry	36	38	42	Vance	21
Guil Quarry	40	42	43	Guilford	36
High Point Quarry	33	35	37	Guilford	37
Ivey Bluff Quarry*	32	31	34	Caswell	40
McLeansville Quarry	23	24	27	Guilford	35
Mt. Airy Quarries	52	54	53	Surry	45
Neverson Quarry	31	32	35	Wilson	10
Pearman Quarry*	50	50	51	Guilford	37
Penrose Quarry*	29	27	32	Transylvania***	49
Person Quarry*	26	27	30	Person	44
Lassiter Quarry	61	66	64	Wake	18
W. E. Graham Quarry	25	25	27	Forsyth**	40
Winston-Salem Quarry	48	51	53	Forsyth	34
Woodleaf Quarry	32	34	36	Rowan	38

* Non-Commercial Quarry
** Biotite-gneiss
*** Comparable to Henderson County stone

Soundness: The soundness of crushed rock or its resistance to the action of freezing and thawing is determined in much the same manner as for dimension stone but is yet unstandardized. Usually, the sized and dried aggregate sample is immersed in a saturated solution of sodium sulphate, kept at a reasonably constant temperature of 70°F. for approximately 18 hours, removed, and dried in an oven at 105° to 110° C. for several hours. Following the oven drying, the sample is exposed to room temperature for several hours more. The chemical and structural effects of the action of the solution on the stone are determined after

each cycle of the process by visual inspection and screening. The test duplicates the natural freezing and thawing processes of nature by the forces exerted on the liquid-filled pores of the stone during the crystallization of the dissolved solids contained in the sulphate solution.

Mechanical Analysis: Tests for size and mechanical analysis of crushed stone are made by the use of square-opening sieves, conforming to United States Bureau of Standards sieve sizes.

For details concerning the various methods of testing both dimension and crushed stone, the reader is referred to "The American Society for Testing Materials Standards," Part II, 1946.

ECONOMIC ASPECTS

ECONOMIC VALUE

The utilization of stone resources, especially granite, in North Carolina has resulted in a mineral industry unequalled in size in the State. Since 1900, the value of quarried granite products in all forms has shown a continued increase, and in 1950 it approached an annual value of $8,500,000.00. This figure represents approximately 32 percent of the total income derived from the sale of raw minerals and mineral products in North Carolina during the same year. In comparison, the 1950 production of industrial minerals (mica, clay, feldspar, pyrophyllite, talc), for which the State is well known, accounted for 35 percent of the total, an amount only slightly larger than that attributable to granite products. Therefore, as a mineral product the income from marketed granite surpasses that of other individual minerals and essentially equals the total for nonmetallics, excluding sand and gravel.

Table IV shows the percentage relationships of the worth of granite products to the total value of exploited minerals in North Carolina during selected years since 1900. It also reflects the direct relationship of income from granite quarrying to the mining economy of the State. The sale of crushed granite, of which North Carolina is the Nation's largest producer, is responsible for about 80 per cent of the total granite sales in the State during 1950.

TABLE IV. PERCENTAGE RELATIONSHIP OF GRANITE PRODUCTS TO TOTAL VALUE OF MINERALS PRODUCED IN NORTH CAROLINA, 1900-1950

Year	*Total Value All Minerals*	*Total Value Granite*	*Percentage Value Granite*
1900	$ 1,604,078	$ 294,000	17
1910	2,848,446	839,742	29
1920	8,117,916	1,968,912	24
1930	10,086,495	3,473,406	32
1940	16,483,732	4,125,518	25
1950	26,343,000	8,500,000	32

MARKET VALUE AND TRANSPORTATION

Dimension Stone: Dimension granite is a relatively high-priced commodity; consequently, distance to market and cost of transportation are not generally considered important economic factors in the production of superior quality stone. This is especially true of stone unique to a particular area, such as, Rowan County and Surry County, from which pink and white granites, respectively, are marketable at high prices in many parts of the United States. Transportation costs for large blocks of granite are high, but quality stone demands a price which offsets the added expense of long-distance shipping. Current prices (1950) for block granite for the monument trade range from about $3 to $5 per cubic foot (160 lbs.) for rough stone, to $12 and up for dressed stone. Prices for rough and finished building stone of corresponding quality run slightly lower. The Northeast and Central United States constitute the normal maximum distances to which North Carolina granite is shipped, but the pink variety from Rowan County has been marketed in recent years in Hawaii. The movement of dimension granite to these markets is about equally divided between rail and motor conveyance. Ordinarily, rough or unfinished stone is transported to finishers by rail and manufactured blocks are moved by motor freight to market areas.

Crushed Stone: Crushed granite, in direct contrast to dimension granite, is a low-cost commodity in which the transportation factor is the primary economic consideration. This factor results from the wide distribution of many types of stone suitable for crushing and the availability of natural gravel in some areas. Because of this widespread availability of stone and gravel, the market for crushed stone is necessarily at close proximity to the quarrying operation and is usually a local product for use by local markets, seldom being carried by trucks to points more distant than 30 miles or by rail more than 100 miles from the quarry. In North Carolina, however, crushed granites and related rocks from the Piedmont region are sometimes marketed in Coastal-Plain cities more distant from the quarry, a transportation factor brought about by the scarcity of crystalline rocks for crushing within the Coastal Plain Province. In order to meet competition, crushed granite is currently sold at prices ranging from $1.10 to $1.75 per ton delivered to consumer conveyance at the quarry.

PRODUCTION

Dimension Stone: Production data for the early years of the stone industry in North Carolina are not available; however, it is estimated from incomplete statistics that a total of some 3,500 short tons, or 41,000 cubic feet, of dimension granite were produced in the State during 1901. The calculated figure of short-ton production was determined by dividing the total value of dimension granite by an average unit value per ton, based on products from another granite-producing area, Barre, Vermont. The number of cubic feet produced was obtained by multiplying the figure estimated as short-ton production by twelve, the approximate number

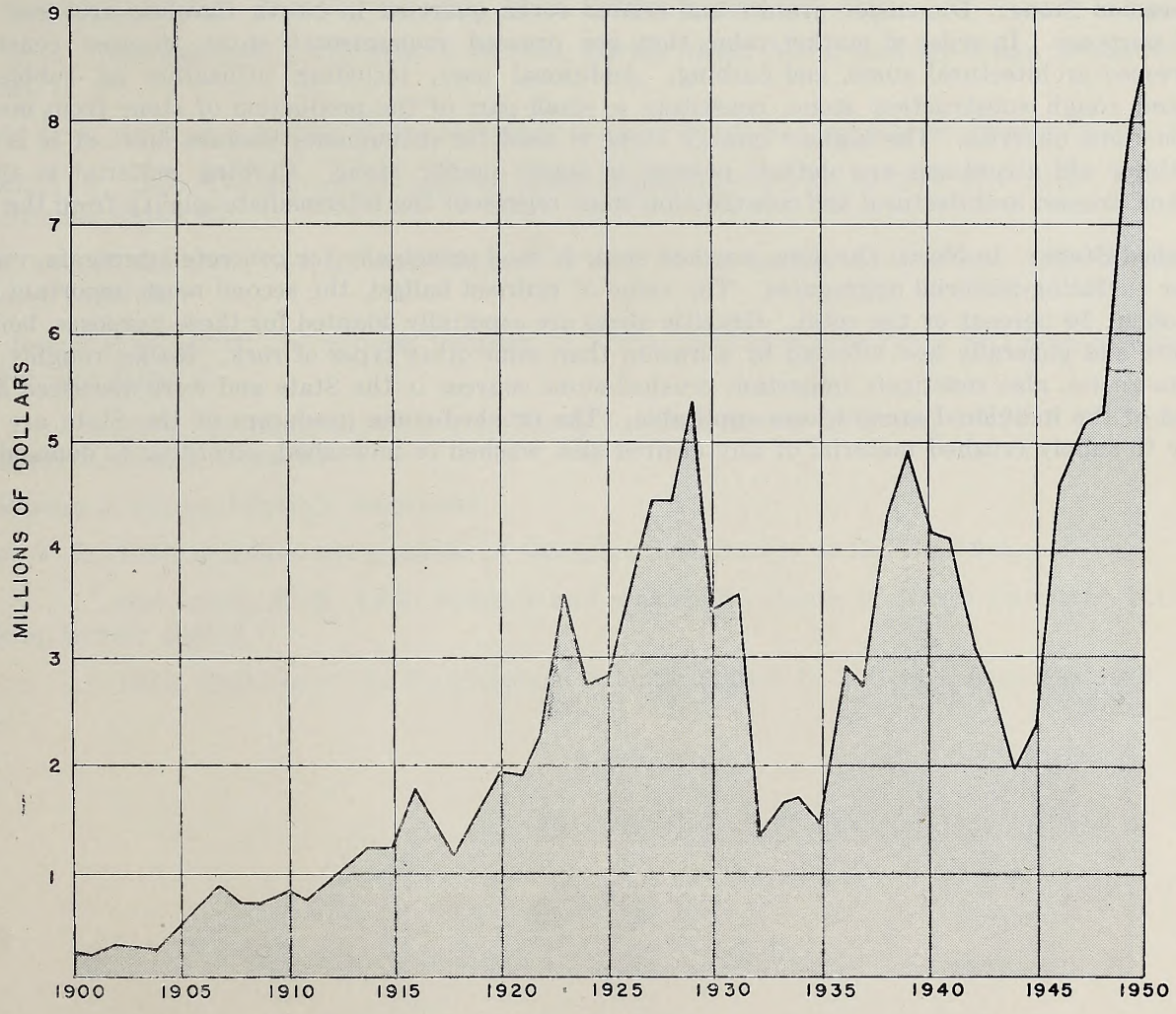

FIGURE 8: VALUE OF GRANITE AND RELATED ROCKS IN NORTH CAROLINA, 1901-1950

of cubic feet contained in a ton of granite. The number of cubic feet per short ton of granite is based upon a specific gravity of 2.60, a figure reduced slightly for convenience.

Production figures for 1950 reveal a 700 percent increase (287,000 cubic feet) in both the production and value of marketed dimension granite. The substantial increase is attributable principally to the continued growth in popularity of the superior grade white granites of the Mt. Airy district and the pink granites of the Salisbury area in the building and monument industries. At present, these two sections are responsible for almost the entire output of dimension granite marketed by North Carolina quarrymen, production being restricted largely to rough and finished monumental and constructional stone and small quantities of curbing, paving block, and rubble.

Crushed Stone: The increased use of crushed rock for concrete aggregate and highway construction, beginning early in the century, is now largely responsible for an annual production in excess of 5,000,000 tons, an increase of over 3,000 percent in less than 50 years. The products from crushed-stone quarries in North Carolina include various standard sieve sizes for highway construction, concrete aggregate, railroad ballast, and minor amounts for use in filter beds and for other domestic purposes.

Figure 8 shows the combined annual value of dimension and crushed granite since 1900, and it reflects generally the relative production for the corresponding years.

USES

Dimension Stone: Dimension granite and related rocks quarried in North Carolina are used for four principal purposes. In order of market value, they are dressed monumental stone, dressed constructional stone, dressed architectural stone, and curbing. Additional uses, including utilization as rubble, paving blocks, and rough construction stone, constitute a small part of the production of stone from most of the dimension-stone quarries. The highest quality stone is used for monuments because most of it is polished, and polishing will accentuate any defects present in lower quality stone. Curbing material is the lowest quality, and dressed architectural and construction stone represent the intermediate quality from the quarries.

Crushed Stone: In North Carolina, crushed stone is used principally for concrete aggregate, road metal, and other surfacing-material aggregates. The value of railroad ballast, the second most important use, constitutes about 10 percent of the total. Granitic rocks are especially adapted for these purposes, being chemically inert and generally less affected by abrasion than some other types of rock. Rocks, roughly classified as granite-gneiss, also constitute important crushed-stone sources in the State and were discussed in the descriptions of the individual areas where applicable. The crushed-stone producers of the State are equipped generally to supply crushed material of any desired size, washed or unwashed, according to demand.

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